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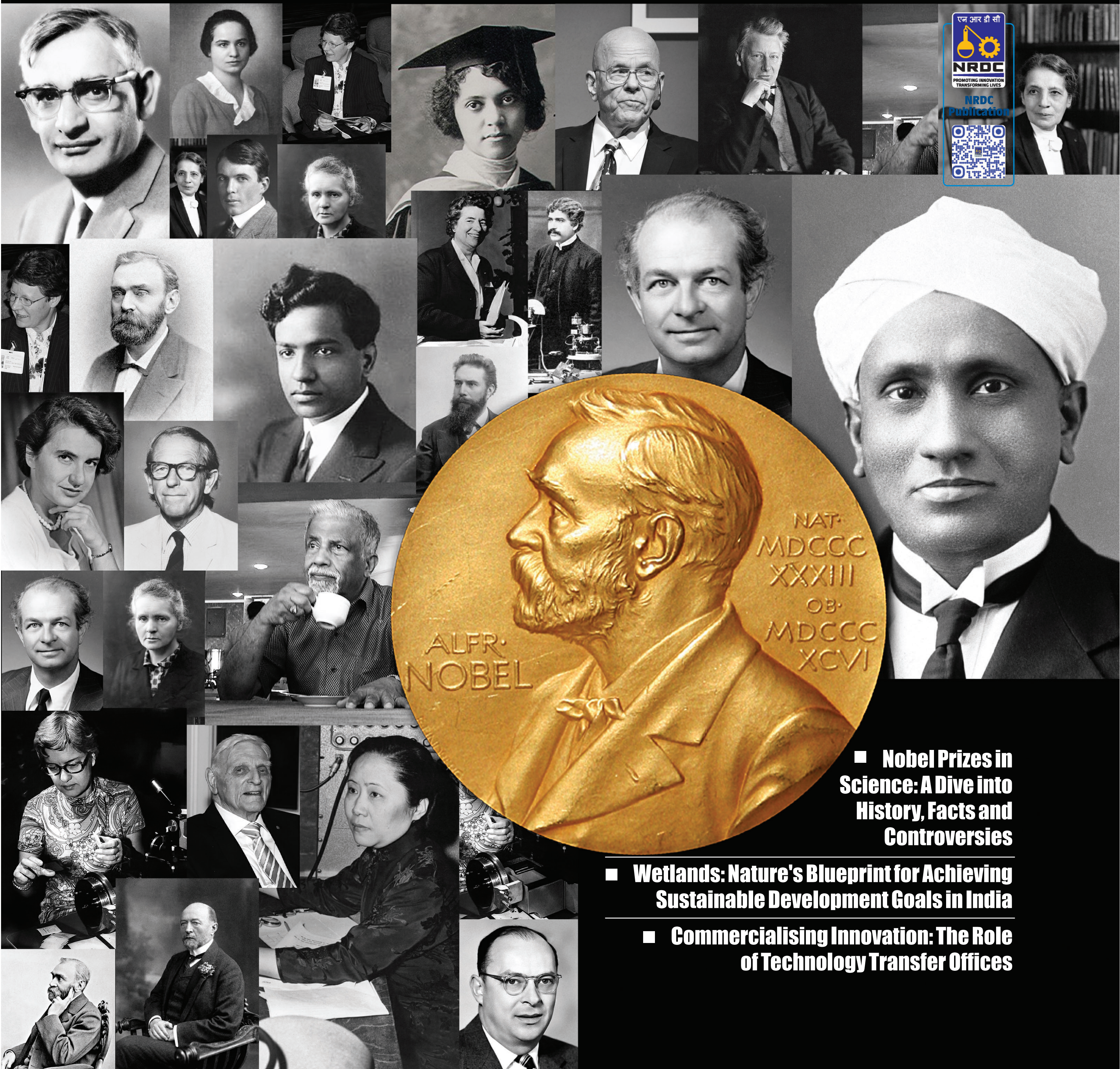
BI-MONTHLY SCIENCE & TECHNOLOGY MAGAZINE

SEPTEMBER-OCTOBER 2025

INVENTION INTELLIGENCE



एन आर डी सी
NRDC
PROMOTING INNOVATION TRANSFORMING LIVES
NRDC Publication

- Nobel Prizes in Science: A Dive into History, Facts and Controversies
- Wetlands: Nature's Blueprint for Achieving Sustainable Development Goals in India
- Commercialising Innovation: The Role of Technology Transfer Offices

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From the Desk of CMD

Dear Readers,

The National Research Development Corporation (NRDC) continues to strengthen the national innovation ecosystem by fostering technology transfer, commercialisation and capacity building. In alignment with the Government of India's vision of *Atmanirbhar Bharat* and Make in India, NRDC plays a vital role in bridging the gap between research and industry, ensuring that indigenous innovations reach society and contribute to sustainable growth.

'The Innovate in Tamil Nadu IP Conclave', inaugurated by Hon'ble Deputy Chief Minister Thiru Udhayanidhi Stalin and graced by key dignitaries, reflects the collective commitment to positioning Tamil Nadu as an IP Capital of India and a hub for innovation-led development. NRDC facilitated significant technology transfers during the conclave, including the Recombinant Ectoine technology from deep sea bacteria, developed by National Institute of Ocean Technology (NIOT) and licensed to Varee Ayustruct Ventures. Such initiatives not only promote commercialisation but also align with global priorities of sustainability, health and industrial competitiveness.

A transformative example of NRDC's technology portfolio is the peptide-based therapeutic for Parkinson's disease. With over 10 million people affected globally, this innovation represents a paradigm shift from symptomatic treatment to a disease-modifying approach. By targeting alpha-synuclein aggregation, demonstrating blood-brain barrier penetration, and securing patent protection, this technology showcases India's capability to deliver world-class health solutions. This is fully aligned with the national focus on healthcare innovation, affordable therapeutics, and global leadership in biotechnology.

The MoU between NRDC and Tamil Nadu Technology Hub (iTNT) is another significant milestone towards strengthening the innovation ecosystem. This collaboration will foster capacity building, IP commercialisation and entrepreneurship, contributing to the Start-up India and Digital India missions.

In its commitment to continuous learning and capacity building, NRDC officials also participated in the DANIDA Fellowship Programme on ISO Innovation Management, sponsored by the Ministry of Foreign Affairs, Denmark. The initiative aimed at enhancing capacity in technology transfer and commercialisation by providing international exposure and practical training in global innovation management practices. Such programmes strengthen NRDC's culture of innovation and reinforce its leadership role in drivingtechnology transfer and commercialisation nationwide As a national institution, NRDC supports technology transfer through licensing, incubation and collaborative partnerships that connect research institutions with industry. Additionally, through design clinic facilities, innovators and MSMEs are provided with access to design expertise, prototyping support and IP advisory services, enabling them to translate ideas into market-ready, sustainable products. These interventions ensure that Indian innovations are globally competitive while serving societal needs.

In keeping with this endeavour, *Invention Intelligence* is carrying articles on Nobel Prizes in Science: A Dive into History, Facts and Controversies; Wetlands: Nature's Blueprint for Achieving Sustainable Development Goals in India; The Spurt of Innovations in Biotechnology: Pushing Fiction Closer to Reality; and many more.

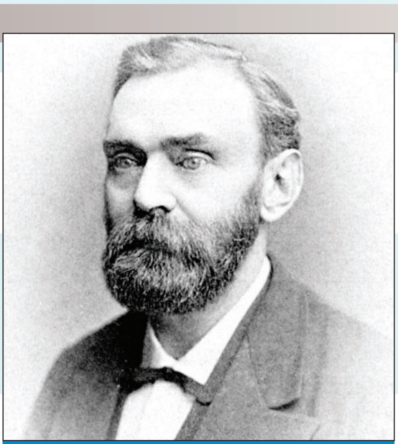
I convey my best wishes for a successful publication of this issue of the magazine.

Jai Hind !

Nobel Prizes in Science: A Dive into History, Facts and Controversies

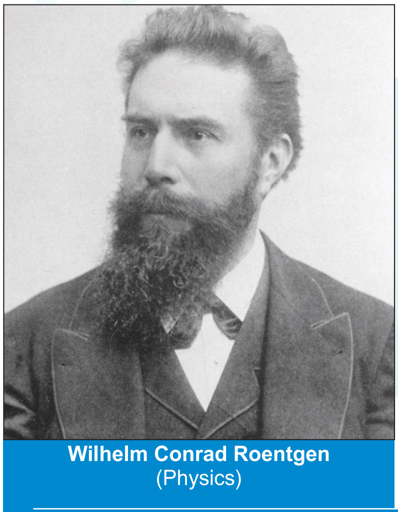
Dr. Subodh Mahanti

The Nobel Prize, named after its creator Alfred Nobel, is widely regarded as most prestigious award worldwide. The Nobel Prize has been awarded since 1901 in the fields of Physics, Chemistry, and Physiology or Medicine. The Nobel Prize is also awarded in the fields of literature and peace since 1901. In 1968, the Swedish Central Bank, Sveriges Riksbank on the occasion of its celebrating its 300th anniversary established a prize in economic sciences in memory of Alfred Nobel. This prize, though named the Sveriges Riksbank Prize, is usually referred to as Nobel Prize. The first prize in economic sciences was given in 1969.


Alfred Nobel
The creator of Nobel Prizes

Nobel Prizes are awarded to individuals or organisations "who have conferred the greatest benefit to humankind in the preceding 12 months", according to the will of Alfred Nobel, the creator of the prizes. Hundreds of individuals have been awarded Nobel Prizes for their landmark discoveries which have played a significant role in shaping our understanding of the natural world and improving human condition. Between 1901 and 2024, the Nobel Prizes and the Sveriges Riksbank Prize in Economic Sciences in Memory of Alfred Nobel were awarded 627 times to 1012 people/organisations. With some receiving the Prize more than once, this makes a total of 976 individuals and 28 organisations.

The present article mostly deals with the Nobel Prizes in scientific


Wilhelm Conrad Roentgen
(Physics)

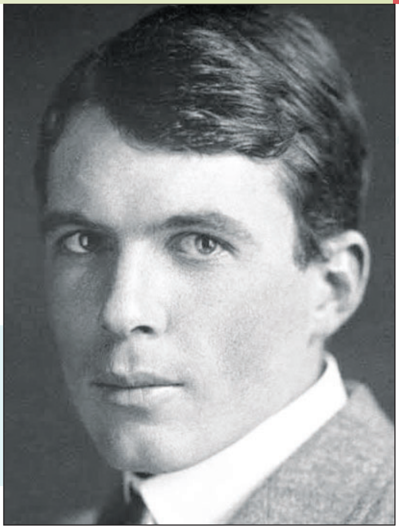
Jacobus H. van't Hoff
(Chemistry)

Emil von Behring
(Physiology or Medicine)

The recipients of the first Nobel Prizes in science in 1901

Marie Curie
The first woman to receive the Nobel Prize in science and also the first person to win two Nobel Prizes (Physics, 1903 and Chemistry, 1911)

John Bardeen
The only person to receive Nobel Prize in Physics twice (1956 & 1972)



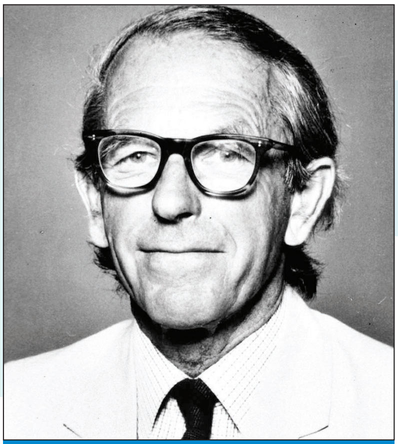
William Lawrence Bragg
The youngest person to receive a Nobel Prize in science, who shared the 1915 Physics Nobel Prize with his father William Henry Bragg at the age of 25

fields. Every year, the world pauses to celebrate the Nobel Prizes– awards that have turned scientists into legends (it is also true that many became legends even before receiving the Prize) and discoveries into milestones. But behind the glitz and glory lies a fascinating story of ambition, controversy, and the relentless pursuit of knowledge. Ralf Petterson

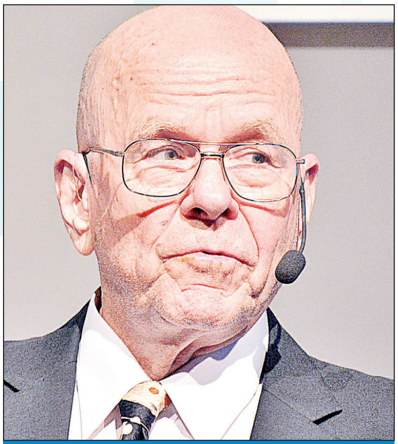
(1945-2011), who served as the Chairman of the Nobel Prize Committee for Physiology or Medicine, said: "As in the past, awarding Nobel Prizes will always depend on discoveries that establish new concepts, open up new lines of research or, in some cases, develop a new powerful technology that changes the course of science. The essence of Nobel Prize is-and not all people realise this-that we go up the river to see where the river started. We want to award these people who really made the crucial, eye-opening discovery. We therefore strictly adhere to the main criterion of awarding the prize 'for a discovery' as stated in Alfred Nobel's will" (quoted from "The Nobel Prizes in new century" in EMBO Reports, February 15, 2001; 2(2):83-85, https://www.ncbi.nim.nih.gov).

The origin

The creator of the Nobel Prize Alfred Nobel was one of the pre-eminent inventors and industrialists of his time. Nobel signed his last Will at the Swedish-Norwegian Club in Paris on 27 November 1895. He bequeathed 94 per cent of his total assets, which was 31 million Swedish kronor equivalent to 266 million US dollars at the rate of 2024, to establish and endow the five Nobel Prizes. The full text of Alfred Nobel's Will can be seen at https://nobelprize.org/alfred-nobel/full-text-of-alfred-nobels-will-2/. It may be emphasised that in his Will Nobel wrote, "it is my express wish that when awarding the prizes, no consideration be given to nationality, but that the prize be awarded to the worthiest person,



Frederick Sanger



Karl Barry Sharpless

The only two persons who received Nobel Prize in Chemistry twice-Sanger (1958 & 1980) and Sharpless (2001 & 2022) whether or not Scandinavia."

What really prompted Nobel to establish the prizes? "Alfred Nobel had a vision of better world. He believed that people are capable of helping to improve society through knowledge, science and humanism. This is why he created a prize that would reward the discoveries that have conferred the greatest benefit to humankind. Since 1901, the Nobel Prize has been awarded in the fields of physics, chemistry, physiology or medicine, literature and peace, while a memorial prize in economic sciences was added in 1968" (https://www.nobelprize.org). This may be regarded as the official version of Nobel's motivation for creating the Prizes. It may be noted that Nobel himself never spoke about the motivation behind his decision to pledge his personal wealth towards establishment of the prizes. According to a commonly repeated story, Nobel was motivated to create the prizes after his mistaken obituary was published. In 1888, his brother Ludvig Nobel (who was known as 'Russian Rockefeller' for his role in establishing the country's oil industry) died in France. The European press mistook Ludvig for Alfred. One newspaper in its obituary depicted Alfred Nobel as 'merchant of death', because of his dealings with explosives. It went on to say that it is because of Alfred Nobel it became possible 'to kill more people more quickly' than it was possible ever before. The veracity of this version cannot be established with certainty that Alfred Nobel was moved by the newspaper reports to establish the prizes. It might be quite possible that even otherwise Nobel wished to compensate for the destructive effect of his inventions and his deep involvement in armament industry by establishing the prizes which would recognise humankind's benefactors.

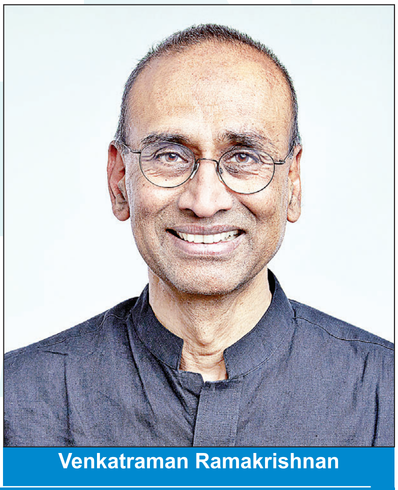
C. V. Raman
He was the first Indian scientist to receive a Nobel Prize in science (Physics, 1930) and he was also the first Asian scientist to receive a Nobel Prize in science

It took five years before an organisation, the Nobel Foundation, could be established for administering the prizes. The first prizes were awarded in 1901.

The ultimate responsibility for fulfilling the intentions in Alfred Nobel's will rests on the Nobel Foundation, a private institution based at Stockholm, Sweden. It was established on 29 June 1900 by the executors of Alfred Nobel's will, Ranger Sohlman and Rudolf Lillijequist. It was based on Nobel's will. It is the legal owner and functional administrator of the funds bequeathed by Alfred Nobel. It strives to ensure a secure strong financial base for maintaining the Nobel Prizes over the long term. The Nobel Foundation also undertakes a number of outreach activities with the intention to inspire and disseminate the knowledge about the Nobel Prize.

Subrahmanyan Chandrasekhar

Har Gobind Khorana

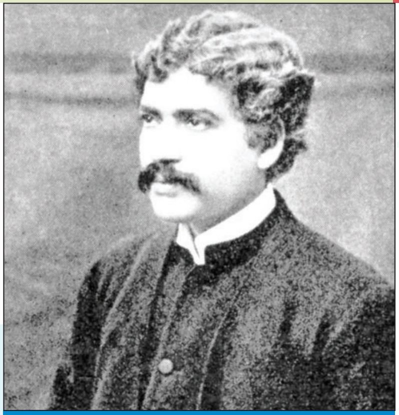


Venkatraman Ramakrishnan

The Indian-born Nobel laureates in science, who, adopted foreign citizenship-Khorana (Physiology or Medicine, 1968), Chandrasekhar (Physics, 1983) and Ramakrishnan (Chemistry, 2009)

John Goodenough
The oldest person to be awarded a Nobel Prize in science,Goodenough was 97 years old when he shared the 2019 Nobel Prize in Chemistry with M. Stanley Whittingham andAkira Yoshino

Linus Pauling
He received two Nobel Prizes (Chemistry, 1954 and Peace, 1962) and he is the only person to receive two unshared Nobel Prizes



J. C. Bose
Many believe that J. C. Bose should have received the Nobel Prize as his inventions like the mercury coherer directly influenced Marconi, who won the 1909 Nobel Prize in Physics jointly with Karl Ferdinand Braun for the development of wireless telegraphy but did not credit Bose's contributions. Bose was the first to use semiconductor junctions to detect radio waves

Nobel's will also named the following four award-giving organisations located in Sweden and Norway:

1. The Royal Swedish Academy of Sciences, which confers the prizes for physics and chemistry. It also confers the prize in economic science established in 1969. The Royal Swedish Academy of Sciences, which was established in 1739 at Stockholm, is an independent, non-government scientific organisation. Its main objective is 'to promote the sciences and strengthen their influence in society'.
2. The Karolinska Institute, which confers the prize for Physiology or Medicine. This is a research-based medical university, and it is located in Solana within the Stockholm urban area of Sweden. It is one of the world's foremost medical universities.
3. The Swedish Academy, which confers the prize for literature. It is one of the royal academies of Sweden and which was established in 1786 by King Gustav III. The Academy is composed of 18 members, and they are elected for life. Known as the 'The Aderton' (The Eighteen), it is the highest Swedish language authority.
4. The Norwegian Nobel Committee, which confers the prize for peace. It consists of five members appointed by the Parliament of Norway.

The Nobel Foundation is governed by a Board of Directors. The Board consists of seven members and two deputy members. They are elected by the Trustees of the prize-awarding organisations for a period of two years. There are a total of 15 Trustees appointed by the four award-giving organisations– six by Royal Swedish Academy of Sciences and three each by the remaining three namely, the Karolinska Institute, the Swedish Academy and the Norwegian Nobel Committee. The Board members elect a Chairman, a Vice-Chairman and an Executive Director.

The components of the Nobel Prize

Each Nobel Prize consists of three things– a medal, a diploma bearing a citation and a monetary award.

The Nobel Prize Medal: The Nobel Prize medal is a gold medal. All medals have some differences except physics and chemistry that look the same. Every medal features a portrait of Nobel on the front. On the medals for physics, chemistry, physiology or medicine and literature the name of the laureate is engraved fully visible on a plate on the reverse. The name of the peace laureate as well as that of the laureate for the prize in economics is engraved on the edge of the medal. The reverse side of the Physics, Chemistry, Physiology or Medicine and Literature medals bear the same inscription; "Inventasvitamiuvatexcoluisse per artes" (It is beneficial to have improved (human) life through discovered arts). The inscription on the reverse side of the Peace medal reads "Pro pace etfraternitatepentium" (For peace and fraternity among people). The Economics medal does not contain any inscription. It was Johan Erik Lindberg (1873-1966), the Swedish sculptor and engraver, who designed the medals for physics, chemistry, physiology or medicine and literature medals. The peace prize medal was designed by the Swedish sculptor Gustav Vigeland (1869-1943), born as Adolf Gustav Thorsen. The designs needed to be approved by each prize-awarding institution. Since 1980, the medals are made of 18-carat recycled

Lise Meitner

Rosalind Franklin

Jocelyn Bell-Burnell

Vera Rubin

Chien-shiung Wu

Marguerite Perey

Alice Ball

Marietta Blau

Many believe that these women scientists should have received Nobel Prizes-Meitner for nuclear fission, Franklin for DNA structure, Bell Burnell for pulsars, Rubin for dark matter, Wu for parity violation in Physics, Perey for discovery of francium, Ball for leprosy treatment and Blau for particle physics (green) gold, plated with 24-carat gold. The weight is set to 175 gram for all medals, except for the medal for Economic Science, the weight of which is set to 185 gram.

The Nobel Diploma: Every Nobel diploma is a personalised piece of artwork. It is handmade for a specific laureate. The text in a Nobel diploma mentions the name of the person who is getting the prize, the year, and includes a short citation explaining the person being awarded the prize. The Peace Prize does not have a citation on the diploma. The original diploma was designed by Gerhard. In 1991, the Nobel Foundation decided that the diploma should be given a new appearance each year by means of an original artwork commissioned from a contemporary Norwegian artist.

The Nobel Monetary Award: Each Nobel Prize is accompanied by a monetary award. The prize award money has fluctuated from under 20,000 to over 1 million US dollars. In the case of more than one awardee, the prize money for a particular work is divided equally. "A prize amount may be equally divided between the two works, each of which considered to merit a prize. If a work is being rewarded has been produced by two or three persons, the prize shall be awarded to them jointly. In no case may a prize amount be divided between more than three persons." (https://www.nobelprize.org/prizes/facts/nobel-prize-facts). The prize money comes from the interest earned on Nobel's original fortune, invested in 'safe securities'.

Nomination for Nobel Prizes

Nomination processes for the Nobel Prizes start in the month of September, the year before the prizes are given out. A nomination will be considered valid only if it is submitted no later than 31 January of the year of the award. Regarding nomination for Nobel Prizes the following points are to be noted:

- Nomination for Nobel Prizes is by invitation only except for the Nobel Peace Prize for which a nomination for the prize may be submitted by any person who meets the nomination criteria.
- The Nobel Committee for each category sends confidential letters of invitation for the nomination.
- No person can nominate herself/himself for a Nobel Prize.
- The names of the nominees and other information about nomination cannot be revealed until 50 years later.

Nominators should meet the following criteria for respective discipline as given below.

Qualified nominators for Physics Nobel Prize

- Swedish and foreign members of the Royal Swedish Academy of Sciences.
- Members of the Nobel Committee for Physics.
- Nobel Prize laureates in Physics.
- Tenured professors in the Physical Sciences at the universities and institutes of technology of Sweden, Denmark, Finland, Iceland and Norway and Karolinska Institute, Stockholm.
- Holders of corresponding chairs in at least six universities or university colleges selected by the Royal Academy of Sciences with a view to ensuring the appropriate distribution over the different countries and their centres of learning.
- Other scientists from whom the Academy may see fit to invite proposals.

Source: https://www.nobelprize.org/nomination/physics/

Qualified nominators for Chemistry Nobel Prize

1. Swedish and foreign members of the Royal Swedish Academy of Sciences.
2. Members of the Nobel Committees for Physics and Chemistry.
3. Nobel Prize laureates in Chemistry and Physics.
4. Permanent professors in the sciences of Chemistry at the universities and institutes of technology of Sweden, Denmark,

When and where the Nobel Prizes are presented

The Nobel Prizes are presented to the laureates on 10 December, the anniversary of Alfred Nobel's death. The Peace Nobel Prize is handed out by the Chairman of the Norwegian Nobel Committee in Oslo in the presence of the King of Norway and the rest five prizes by the King of Sweden in Stockholm's Concert Hall. At Stockholm the presentation ceremony, which is a major international event, is followed by a banquet held at the Blue Hall of Stockholm City Hall. Around 1300 guests attend the banquet.

Finland, Iceland and Norway and Karolinska Institute, Stockholm.

5. Holders of corresponding Chairs in at least six universities or university colleges selected by Royal Academy of Sciences with a view to ensuring the appropriate distribution over the different countries and their centres of learning.
6. Other scientists from whom the Academy may see fit to invite proposals

(Source: https:// www. nobelprize. org/ nomination/ chemistry/)

Qualified nominators for Physiology or Medicine Nobel Prize

1. Members of Nobel Assembly at Karolinska Institute, Stockholm.
2. Swedish or foreign members of the Medicine and Biology classes of the Royal Swedish Academy of Sciences.
3. Nobel laureates in Physiology or Medicine and Chemistry.
4. Members of the Nobel Committee not qualified under paragraph 1 above.
5. Holders of established posts as full professors at the faculties of medicine in Sweden and holders of similar posts at the faculties of medicine or similar institutions in Denmark, Finland, Iceland and Norway.
6. Other scientists from whom the Academy may see fit to invite proposals.

(Source: https:// nobelprize.org/ nomination/medicine/)

When Nobel Prizes were not awarded or deferred

Since the beginning in 1901, there were some years when the Nobel Prizes were not awarded. Most of them were during the two world wars– World War I (1914-1918) and World War II (1939-1945). The statutes of the Nobel Foundation have provision for not awarding the prize if a suitable candidate could not be found. The statutes of the Nobel Foundation state: "if none of the works under consideration is found to be of importance indicated in the first paragraph, the prize money shall be reserved until the following year. If even then the prize cannot be awarded, the amount shall be added to the Foundation restricted funds."

The Physics Nobel Prize was not awarded on six occasions– 1916, 1931, 1934, 1940, 1941 and 1942

The Chemistry Nobel Prize was not awarded on eight occasions - 1916, 1917, 1919, 1924, 1933, 1940, 1941 and 1942.

The Physiology or Medicine Nobel Prize was not awarded on nine occasions– 1915, 1916, 1917, 1918, 1921, 1924, 1940, 1942 and 1943.

In case of Physics Nobel Prize there were nine years for which the Prize was delayed. They were:

1. 1914 (awarded in 1915): Max Theodore Felix von Laue (1879-1960)
2. 1917 (awarded in 1918): Charles Glover Barkla (1877-1944)
3. 1918 (awarded in 1919): Max Karl Ernst Ludwig Planck (1858-1947)
4. 1921(awarded in 1922): Albert Einstein (1879-1955)
5. 1924 (awarded in 1925): Karl Manne Georg Siegbahn (1886-1978)
6. 1925(awarded in 1926): James Franck (1882-1964) and Gustav Ludwig Hertz (1887-1975)
7. 1928 (awarded in 1929): Owen Willans Richardson (1879-1959)
8. 1932 (awarded in 1933): Werner Karl Heisenberg (1901-1976)
9. 1943 (awarded in 1944): Otto Stern (1888-1969)

In case of Chemistry Nobel Prize there were nine years for which the Prize was delayed. They were:

1. 1914 (awarded in 1915): Theodore William Richards
2. 1918 (awarded in 1919): Fritz Haber
3. 1920 (awarded in 1921): Walther Nernst
4. 1921 (awarded in 1922): Frederick Soddy
5. 1925 (awarded in 1926): Richard Zsigmondy
6. 1927 (awarded in 1928): Heinrich Otto Wieland
7. 1938 (awarded in 1939): Richard Kuhn
8. 1943 (awarded in 1944): George de Hevesy
9. 1944 (awarded in 1945): Otto Hahn

In case of Physiology or Medicine Nobel Prize there were five years for which the Prize was delayed. They were:

1. 1914 (awarded in 1915): Robert Barany
2. 1922 (awarded in 1923): Archibald Hill and Otto Fritz Meyerhof
3. 1926 (awarded in 1927): Johannes Fibiger
4. 1938 (awarded in 1939): Corneille Heymans
5. 1943 (awarded in 1944): Henrik Dam and Edward Adelbert Doisy

Some interesting facts about Nobel Prize

- Nobel Prizes are not awarded

posthumously. However, the award is not withdrawn if a person dies after the announcement of the prize but before it could be presented. William Spencer Vickery (1914-1996) is the only person who in 1996 died after the prize in Economics was announced but before it could be presented. There is no such instance in case of science Nobel Prizes.

- The Nobel Prize in Physics has been awarded to 226 individuals as of 2024 and John Bardeen (1908-1991) is the only person to get the Nobel Prize in Physics twice.
- Five women who have been awarded the Nobel Prize in Physics are: Marie Curie (1903), Maria Goeppart-Mayer (1963), Donna Theo Strickland (2018), Andrea Mia Ghez (2020) and Anne L'Huillier (2023).
- The Nobel Prize in Chemistry has been awarded to 197 individuals as of 2024 but because Frederick Sanger and Barry Sharpless won twice, the count of individual people is 195.
- Eight women have been awarded the Nobel Prize in chemistry namely, Marie Curie (1911), IIrene Joliot-Curie (1935), Dorothy Crowfoot Hodgkin (1964), Ada E. Yonath (2009), Frances Hamilton Arnold (2018), Emmanuelle Charpentier (2020), Jennifer Anne Doudna (2020) and Carolyn Ruth Bertozzi (2022).
- The Nobel Prize in Physiology or Medicine has been awarded to 229 individuals as of 2024.
- No one has been awarded the Nobel Prize in Physiology more than once.
- Thirteen women have received the Nobel Prize in Physiology or Medicine namely, Gerty Theresa Cori (1947), Rosalyn Sussman Yalow (1977), Barbara McClintock (1983), Rita Levi-Montalcini (1986), Gertrude 'Trudy' Belle Elion (1988), Christiane Nusslein-Volhard (1995), Linda Brown Buck (2004), Francoise Barre-Sinoussi (2008), Elizabeth Helen Blackburn (2009), Carol (also Carolyn) WidneyGreider (2009), May-Britt Moser (2014), Tu Yo-yo (2015), and Katalin 'Kati' Kariko (2023).
- Marie Curie is the only person to be awarded a Nobel Prize in two different sciences.
- Linus Pauling is the only person to receive more than one unshared Nobel Prize– Chemistry Nobel Prize (1954) and Peace Nobel Prize (1962).
- Nobel Prize has not been shared by more than three individuals.
- William Lawrence Bragg remains the youngest person to receive a Nobel Prize in Physics. He received the 1915 Physics Nobel Prize (jointly with his father William Henry Bragg) at the age of 35.
- The youngest Nobel Prize winner in Chemistry is Frederick Joliot-Curie, who was 35 years old when he shared the Chemistry Nobel Prize in 1935 with his wife Irene Joliot-Curie.
- Frederick Banting (1891-1941) remains the youngest person to win a Nobel Prize in Physiology or Medicine (1923) at the age of 32.
- John Bannister Goodenough (1922-2023) is the oldest person to win a Nobel Prize in science. He received the prize at the age of 97. He was awarded the 2019 Chemistry Nobel Prize jointly

The 'Nobel lag' - delay in receiving the Nobel Prize

A Nobel laureate may receive the prize decades after the award-winning discovery was made. It seems waiting for over 20 years is becoming a norm. "The road to a Nobel Prize, the most prestigious scientific award in the world, is growing ever longer, with almost half of laureates now waiting more than 20 years from making a Nobel-worthy discovery to receiving the prize. Our analysis shows that the average time between publishing the work and receiving one of the science prizes has nearly doubled in the past 60 years. Across the three science prizes, chemistry has the longest 'Nobel lag'– an average of 30 years over the past decade– and Physiology or Medicine has the shortest, at 26 years" (quoted from "Nobel Prizes Are Taking Longer to Award Groundbreaking Research" by Lilly Tower and *Nature* Magazine, and Scientific American, October 4, 2023, https:// www. scientificamerican.com).

There may be many reasons for the delay. Some possible reasons are:

- Number of breakthroughs are increasing each year and as a result the Nobel Prize is unable to keep up with number of deserving people.
- The realisation of the significance of some works takes years or decades.
- Paradigm-changing discoveries are decreasing, prompting selectors to look increasingly toward the past.

Subrahmanyan Chandrasekhar's case was very unusual. He shared the 1983 Physics Nobel Prize for his work on stellar structure in the 1930s.

with Michael Stanley Whittingham and Akira Yoshino 'for the development of lithium-ion batteries.'

Five scientists have received two Nobel Prizes. They are:

1. Marie Curie– Physics (1903) and Chemistry (1911)
2. Linus Pauling– Chemistry (1954) and Peace (1962)
3. John Bardeen– Physics twice (1956 and 1972)
4. Frederick Sanger– Chemistry twice (1958 and 1980)
5. Karl Barry Sharples– Chemistry twice (2001 and 2022)

Four couples have been awarded the Nobel Prize in science:

1. Marie Curie (1867-1934) and Pierre Curie (1859-1906) were jointly awarded the 1903 Physics Nobel Prize.
2. Irene Joliot-Curie (1897-1956) and Frederick Joliot-Curie (1900-1958) were jointly awarded the 1935 Chemistry Nobel Prize.
3. Gerty Theresa Cori (1896-1957) and Carl Ferdinand Cori (1896-1984) shared the 1947 Nobel Prize in Physiology or Medicine.
4. May-Britt Moser (1963-) and Edvard Ingald Moser (1962-) shared the 2014 Nobel Prize in Physiology or Medicine.

There are six father-son pairs who have won the Nobel Prize in science.

1. Joseph John Thomson (1906, Physics) and George Paget Thomson (1937, Physics).
2. William Henry Bragg (1915, Physics) and William Lawrence Bragg (1915, Physics).
3. Niels Bohr (1922, Physics) and Aage Bohr (1975, Physics).

Controversies surrounding the Nobel Prize

The Nobel Prizes are not free from controversies. It is true that there are more controversies in Peace, Literature and Economics compared to sciences. In science, controversies occur because of overlooking worthy candidates and in some cases recognising individuals who eventually proved to be poor choices. There are also discussions on racial and gender discriminations. It has been argued that at least women in science have got some recognition but so far no black person has won a science Nobel (there are 17 Black winners in total across peace, literature and economics prizes). The case of Charles Richard Drew (1904-1950) and Percy Lavon Julian (1899-1975) have been cited to point out how Black persons have been overlooked. Drew discovered a method for long-term storage of blood plasma. Julian who first synthesised the drug physostigmine previously only available from plants. Julian was a pioneer in the chemical synthesis of medicinal drugs from plants. His work laid the foundation for the steroid drug industry's production. His work on artificial hormones eventually led to birth control pills. The rules/guidelines formulated in Nobel's will are themselves responsible for creating controversies. According to the rules of the Nobel Foundation each award cannot be shared by more than two different research works and no more than three different individuals. The convention of limiting each prize to only three individuals lead to misleading impression of how science actually advances. Each advance in science, particularly in recent times, is very often a team effort. This point can be substantiated by citing the example of the 2011 Physics Nobel Prize. It was given to three astronomers - Saul Perlmutter, Brian Schmidt and Adam Riess for the discovery that the expansion of the universe is not slowing down as one would expect if the gravitational pull that galaxies exert on each other is taken into account. The important point is that this discovery for which the Nobel Prize was given was achieved independently by two teams, each having about 25 members. However, when the prize was given only three individuals were selected - two from one team and one from the other irrespective of the fact that in each team there were several as distinguished as those of the awardees. In some cases the discovery may be shown as the result of a well-defined team effort but then several researchers worked on the same topic and reached the finishing-line almost simultaneously. The 2013 Nobel Prize for physics given for the discovery of Higgs Boson falls under this category. The Nobel Prize was given to Francois Englert and Peter W. Higgs. The members of the team at the CERN lab at Geneva who conducted the experiment that actually made the discovery was not given the credit. The contribution of Tom Kibble (1932-2016) who with Peter Higgs discovered the 'Higgs-Kibble Mechanism' for giving mass to the fundamental particles of the universe was also ignored while giving the Nobel Prize.

The rule that the Nobel Prize cannot be given posthumously creates lot of controversy, because of this rule deserving people who pass away before their work is fully recognised are automatically excluded from the glory. This really creates awkward situations. The case of Rosalind Franklin is a striking example. Her work was extremely crucial in elucidating the structure of DNA but because of her untimely death her contribution was not given due recognition.

The entire corpus of science does not come under the purview of the Nobel Prize. Nobel created three prizes in science– Physics, Chemistry and Physiology or Medicine. While it is true that with the passage of time these three disciplines are interpreted to take into account the changing contour of science, however, this is not sufficient. Large tracts of science still remain outside the domain of the Nobel Prize. For example, mathematics, environmental sciences, robotics, artificial intelligence and others are yet to be covered. (See "Nobel Prizes are still failing to celebrate the diversity of science" by Alexander Thomson, New Scientist, 9 October 2024, https:// www. newscientist.com). Here it may be noted that Fields Medal and the Abel Medal are regarded as alternative to Nobel Prize in Mathematics.

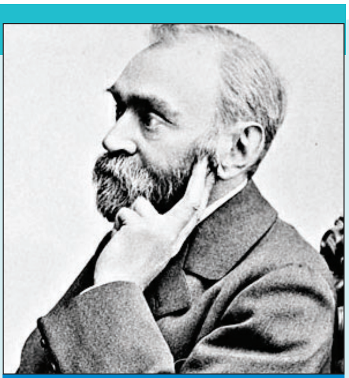
Alfred Nobel

Alfred Bernhard Nobel (commonly known as Alfred Nobel) is the creator of the Nobel Prizes, widely regarded as the most prestigious award in the world. Alfred Nobel was born on 21 October 1833 in Stockholm, Sweden to Immanuel Nobel (1801-1872) and Andretti Nobel (1805-1889). His father was an inventor and engineer.

In 1838, when Alfred Nobel was five years old, his father moved to St. Petersburg. His family followed him there in 1842. The worsening financial situation was the main reason for the Nobel family to move to St. Petersburg. After going bankrupt in 1833, Immanuel could not recover to start business again in Sweden and so he opted for St. Petersburg. In St. Petersburg Immanuel Nobel became a successful manufacturer of machine tools and explosives. He also invented here the veneer lathe which made possible the production of plywood and also developed naval mines (underwater exploding mines) which were used during the Crimean War (1853-1856). At St. Petersburg, Alfred Nobel studied with the Russian chemist Nikolai Nikolaevich Zinin (1812-1880). He left St. Petersburg in 1850 to spend a year in Paris and then to visit USA. In Paris he met the inventor of nitroglycerin, Ascanio Sobrero (1812-1888), an Italian chemist. He returned to St. Petersburg in 1852 and started working in his father's factory. However, after the Crimean War, the financial situation of the Nobel family became critical. After their factory went bankrupt, Emanuel moved back to Sweden with his wife and two sons Emil and Alfred. Alfred's brothers Robert and Ludvig remained in Russia 'to salvage what was left of the family business.' They later developed newly discovered oilfields near Baku, which made them immensely wealthy. After coming back to Sweden, Alfred Nobel invented an explosive device blasting cap, which was basically an improved version of detonator. It is said that the blasting cap's invention inaugurated the modern use of high explosives. His most famous invention was dynamite, which was patented in 1867. Dynamite is nitroglycerin-based explosive but it can be handled much safer than nitroglycerin alone. Dynamite established Alfred Nobel's reputation as an explosive expert worldwide. He also invented gelignite in 1875. It was a more powerful form of dynamite. In 1887, he introduced ballistite, one of the first nitroglycerin smokeless powders. A precursor of cordite, ballistite was a big step forward in explosives technology. It was Alfred Nobel who had developed Bofors, which was originally an iron and steel producing company, into a major manufacturer of canons and other armaments. Alfred Nobel had acquired 355 patents before his death. Besides his work on explosives and other business ventures, he also experimented in making synthetic rubber, leather and artificial silk among others. He was elected a member to the Royal Swedish Academy of Sciences. Alfred Nobel died on 10 December 1896 at San Remo, Italy. The artificially created or synthetic element nobelium was named after him. It has the symbol 'No' and atomic number 102.

The Nobel legacy

It can be said that irrespective of certain shortcomings, Nobel Prizes continue to remain as a symbol of human achievement, recognising those whose works have profoundly benefitted humankind. The Nobel legacy continues to remind us that the pursuit of knowledge and the drive to better the existing world remains timeless ideals and it will continue to do so in future. The Nobel Prize celebrates science and scientists who pursue it. We would like to end the article by a quotation of Arthur H. Compton, Nobel laureate in Physics (1927): "The benefits of science are not only material ones. The truths that science teaches us are of common interest the world over. The language of science is universal and is a powerful force in bringing the people of the world closer together." The quotation is from Compton's Nobel Banquet speech in Stockholm on 10 December 1927 and this is the reason why the Nobel Prizes in science should be with renewed interest every passing year.



Portrait of Nobel
by Goesta Florman (1831-1900), a Swedish photographer

4. Karl Manne Georg Siegbahn (1924, Physics) and Kai Manne Borje Siegbahn (1981, Physics)
5. Hans von Euler-Cheplin (1929, Chemistry) and Ulf Svante Euler (1970, Physiology or Medicine.
6. Arthur Kornberg (1959, Physiology or Medicine) and Roger David Kornberg (2006, Chemistry).

While there are six father-son pairs, Pierre Curie and Irene Joliot-Curie remain the only father-daughter pair to receive Nobel Prize in science.

- Marie-Curie and Irene-Joliot-Curie are the only mother-daughter pair to have won a Nobel Prize in science.
- C.V. Raman received the Physics Nobel Prize in 1930, and his nephew Subrahmanyan Chandrasekhar also got Nobel Prize in Physics (1983).
- C.V. Raman was the first Indian to receive a Nobel Prize in a scientific field. He was also the first Asian to receive a Nobel Prize in science.

Deserving candidates missing the Prize

The Swedish biochemist Arne Wilhelm Kaurin Tisellius (1902-1971), a Nobel Prize winner in chemistry and who also served as Vice President and President of the Nobel Foundation, said: "The world is full of brilliant scientists, who never have received the Nobel Prize and never will." Some of the deserving candidates who missed the Nobel Prize in science:

1. **Dmitri Mendeleev (1834-1907):** He formulated periodic law in chemistry and created a version of periodic table of chemical elements. His work not only classified known chemical elements but also predicted the existence and properties of undiscovered elements. He was nominated for the prize in 1905, 1906 and 1907 but he never received the prize.
2. **Henri Poincare (1854-1912):** He was one of the greatest mathematicians and mathematical physicists of his time. He was the first person to discover a chaotic deterministic system which laid the foundations of modern chaos theory.
3. **Nicola Tesla (1856-1943):** He is known for his groundbreaking work in electric power system. He discovered and patented the rotating magnetic field, the basis of most alternating current machinery. His works are fundamental to how electricity is generated, transmitted and used today.collagen and the development of the Ramachandran plot for understanding the peptide structure.

16. **Carl Djerassi (1923-2015):** He is known as the father of contraceptive pill.
17. **Carl Richard Woese (1928-2012):** He discovered Archaea, a third domain of life and revolutionised evolutionary biology.
18. **Vera Rubin (1928-2016):** She pioneered work on galaxy rotation rates. Her work provided convincing evidence for the existence of dark matter in the universe.
19. **E.C.G Sudarshan (1931-2018):** He laid the foundation of the field of quantum optics. His theorem proved the equivalence of classical wave optics to quantum optics. He was the first to propose the theoretical possibility of the existence of particles (now called tachyons) that could travel faster than light.
20. **Jocelyn Bell (1943-):** She discovered the first pulsar.

There will be others who can be included in the above list of deserving candidates who should have got Nobel Prizes.

Some books on different aspects of Nobel Prizes

1. *The Beginnings of the Nobel Institution: The Science Prizes, 1901-1915* by Elisabeth T. Crawford, Cambridge University Press, 1987.
2. *The Nobel Prize: First 100 Years, edited* by Agnata Wallin Levinovitze, World Scientific Publishing Company, 2001.
3. *Nobel Prizes and Life Sciences* by Erling Corby, World Scientific Publishing Company, 2010.
4. *The Nobel Prize: A History of Genius, Controversy and Prestige by* Burton Feldman, Arcade, 2012.
5. *Nobel Prizes and Notable Discoveries* by Erling Corby, World Scientific Publishing Company, 2016.

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Wetlands: Nature's Blueprint for Achieving Sustainable Development Goals in India

Mital Thacker, Karthick Balasubramanian and Kumar Bharat Bhushan

I**magine** standing at the edge of a shimmering lake where water lilies bloom, birds wade gracefully, and dragonflies dance above the water surface. Now, picture a dense mangrove forest where roots emerge from the water, sheltering fish, crabs, and other aquatic life. These are wetlands– nature's thriving intersections of land and water, teeming with biodiversity.

Think of a landscape where land and water meet, creating a bustling hub of life. That's a wetland! These special ecosystems – whether marshes, swamps, peatlands, or seasonal floodplains – are among the biodiversity-rich sites on the Earth.

But wetlands aren't just pretty landscapes; they're nature's hardworking superheroes! Think of them as Earth's kidneys, filtering pollutants and keeping our water clean. They also store carbon, helping to fight climate change and act as giant sponges, soaking up excess water to prevent floods.

But where did the term 'wetland' come from? It was first officially introduced in 1953 by the U.S. Fish and Wildlife Service (USFWS). Simply put, a wetland refers to land that is either partially or fully submerged in water, at least seasonally. Wetlands can vary widely across the globe, so scientists needed a universal definition that could describe these ecosystems, and by 1971, the Ramsar Convention – a global treaty for wetland conservation – provided a clear definition.According to Ramsar, wetlands include "areas of marsh, fen, peatland, or water - whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish, or salt; and interestingly, this definition also includes shallow coastal waters (as long as they're no deeper than six metres at low tide!)."

How nature holds the key to a sustainable future

Have you ever wondered how wetlands contribute to a healthier planet and a better future for all? These vibrant ecosystems do much more than just provide habitat for wildlife– they are key players in achieving global sustainability! The multiple benefits and services provided by wetlands are essential to attain the Sustainable Development Goals (SDGs).

In 2015, the United Nations introduced the Sustainable Development Goals– a set of 17 ambitious targets to tackle the world's biggest challenges, like poverty, hunger, climate change, and biodiversity loss. But you might not know that wetlands are deeply connected to many of these goals!

Why wetlands matter for India's sustainability

India's wetlands cover 4.8 per centof the country's land, supporting biodiversity, regulating climate, providing livelihoods, and ensuring water security. From the mangroves of Sundarbans to the high-altitude lakes of Trans Himalayas, these ecosystems are nature's powerhouses. But rapid urbanisation, pollution, and climate change threaten their survival. Recognising their importance, India – an active member of the Ramsar Convention– has been stepping up conservation efforts. On World Wetlands Day, 2 February 2025, India added four new Ramsar sites, bringing the total to 89 – the highest in Asia and the third highest globally!But why does this matter for sustainability? Simply put, wetlands provide essential services. Before delving into specific SDGs, it's important to understand the broader ecosystem services wetlands provide, which form the foundation for their role in sustainable development. This piece explores how effective conservation and management of wetlands can help India achieve its SDG targets, focussing on ecological sustainability, economic development, and social well-being.

Ecosystem services of wetlands

Wetlands are lifelines for ecosystems and human societies, offering essential ecosystem services.Theyact like sponges, absorbing excess rainwater and reducing flood risks, and then during dry spells, they slowly release stored water, acting as natural shields against floods, droughts, and cyclones. Often called 'Earth's Kidneys', wetlands naturally filter pollutants, improving water quality. They are also powerful carbon sinks, trapping greenhouse gases and mitigating climate change. At the same time, as biodiversity hotspots, they provide homes for incredible wildlife, from majestic migratory birds that travel thousands of kilometres to rare plants and amphibians found nowhere else.Additionally, wetlands prevent erosion, regulate water flow, and support millions of livelihoods through fishing, agriculture, and ecotourism. With cultural, recreational, and educational significance, wetlands are invaluable– yet under threat from urbanisation and pollution. Protecting them is key to a sustainable future, as their ecosystem services are the link that connects wetlands to various SDGs.

How wetlands help achieve the SDGs

Let's connect the dots– how do wetlands directly contribute to the United Nations SDGs?

How do wetlands help achieve SDG-6: Clean water and sanitation?

Goal-6 emphasises the importance of ensuring clean water and sanitation for all.Ever wondered how wetlands help provide clean water? These natural filters trap pollutants and purify water naturally. For example, the East Kolkata Wetlands in West Bengal recycle the city's wastewater while supporting fisheries and agriculture, creating a unique balance between urban waste management and rural livelihoods.Similarly, In India's Musi River, water quality improved significantly after passing through wetlands– a real-world example of nature's own water treatment system!

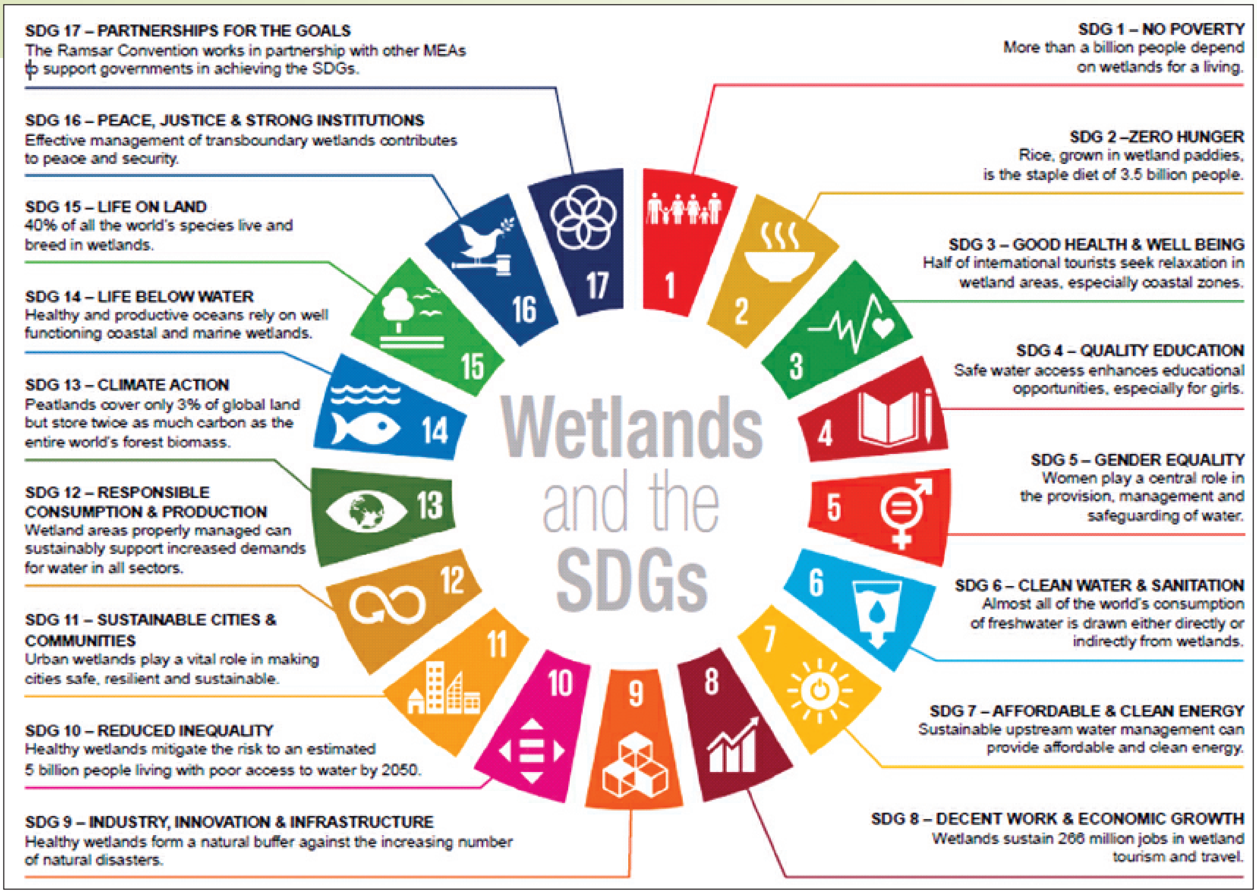
What role do wetlands play in climate action (SDG-13)

To combat climate change, we need natural solutions– and wetlands are one of the best! They store carbon, regulate temperature, and protect against extreme weather. Wetlands like Wular Lake in Jammu & Kashmir regulate the local climate and control floods by absorbing excess water. The Sundarbans Mangroves in West Bengal are a shield against coastal storms, and Point Calimere Wetlands, Tamil Nadu, help absorb carbon from the atmosphere.

Why are wetlands crucial for life on land (SDG-15)

Wetlands are biodiversity havens. Take the Harike Wetland in Punjab, for example– it transforms into a winter sanctuary for migratory birds escaping the harsh cold of Europe and Western Asia. Similar seasonal spectacles unfold across India's wetlands, including the Bharatpur Wildlife Sanctuary in Rajasthan, the Little Rann of Kachchh, and the coastal wetlands of Saurashtra in Gujarat, where thousands of migratory birds arrive each year.

But wetlands don't just host



SDG 17 – PARTNERSHIPS FOR THE GOALS
The Ramsar Convention works in partnership with other MEAs to support governments in achieving the SDGs.

SDG 16 – PEACE, JUSTICE & STRONG INSTITUTIONS
Effective management of transboundary wetlands contributes to peace and security.

SDG 15 – LIFE ON LAND
40% of all the world's species live and breed in wetlands.

SDG 14 – LIFE BELOW WATER
Healthy and productive oceans rely on well functioning coastal and marine wetlands.

SDG 13 – CLIMATE ACTION
Peatlands cover only 3% of global land but store twice as much carbon as the entire world's forest biomass.

SDG 12 – RESPONSIBLE CONSUMPTION & PRODUCTION
Wetland areas properly managed can sustainably support increased demands for water in all sectors.

SDG 11 – SUSTAINABLE CITIES & COMMUNITIES
Urban wetlands play a vital role in making cities safe, resilient and sustainable.

SDG 10 – REDUCED INEQUALITY
Healthy wetlands mitigate the risk to an estimated 5 billion people living with poor access to water by 2050.

SDG 9 – INDUSTRY, INNOVATION & INFRASTRUCTURE
Healthy wetlands form a natural buffer against the increasing number of natural disasters.

SDG 1 – NO POVERTY
More than a billion people depend on wetlands for a living.

SDG 2 –ZERO HUNGER
Rice, grown in wetland paddies, is the staple diet of 3.5 billion people.

SDG 3 – GOOD HEALTH & WELL BEING
Half of international tourists seek relaxation in wetland areas, especially coastal zones.

SDG 4 – QUALITY EDUCATION
Safe water access enhances educational opportunities, especially for girls.

SDG 5 – GENDER EQUALITY
Women play a central role in the provision, management and safeguarding of water.

SDG 6 – CLEAN WATER & SANITATION
Almost all of the world's consumption of freshwater is drawn either directly or indirectly from wetlands.

SDG 7 – AFFORDABLE & CLEAN ENERGY
Sustainable upstream water management can provide affordable and clean energy.

SDG 8 – DECENT WORK & ECONOMIC GROWTH
Wetlands sustain 266 million jobs in wetland tourism and travel.

Image show show wetlands support achievement of the SDGs (Image source: Ramsar Convention on Wetlands Report on Scaling up Wetland Conservation, (2018)

visitors– they also shelter ancient, endemic species. The Myristica Swamps of Kerala and Karnataka, some of the oldest wetlands in India, are home to rare plant and animal species found nowhere else in the world.

The Keoladeo National Park, Rajasthan, is a UNESCO World Heritage Site and a winter refuge for thousands of migratory birds. Without wetlands, countless species could lose their homes.

Chilika Lake in Odisha, Asia's largest brackish water lagoon, was once facing severe ecological degradation. Thanks to community-led restoration and government efforts under the Chilika Development Authority, the lake has returned, supporting over 150,000 fishermen and becoming a biodiversity hotspot again.

How do wetlands reduce poverty and hunger (SDGs-1 & 2)?

Goal-1 aims to end extreme poverty by 2030, ensuring basic needs for all. Food security is at the heart of this effort, bringing us to Goal-2: Zero Hunger. Wetlands provide food and income to millions!Loktak Lake in Manipur supports phumdi-based agriculture and fishing, offering livelihoods to local communities. WhileKolleru Lake in Andhra Pradesh and Chilika Lake in Odisha are hubs for fisheries, sustaining thousands of families who depend on them for income and food.

How can wetlands make cities sustainable (SDG-11)

Urban wetlands make cities more liveable. The Pallikaranai Marsh in Chennai acts as a natural sponge, mitigating urban floods and reducing heat island effects. Vashi Creek Wetlands, Mumbai, help control flooding, while Najafgarh Jheel, Delhi, could be a biodiversity hotspot if appropriately restored. These connections demonstrate that wetlands are not isolated ecosystems but integral to achieving sustainable development across multiple sectors.

Strategies for wetland conservation and management in India

Imagine a world without wetlands– floods would be more destructive, water would be dirtier, and many species would lose their homes. That's why India has taken significant steps to protect these fragile ecosystems. Laws like the Wetlands (Conservation and Management) Rules, 2017, and programmes like the National Wetland Conservation Programme (NWCP) are working to stop wetland destruction and promote their sustainable use. The Sundarbans Biosphere Reserve is an excellent example of how strong policies can safeguard vital landscapes.

But conservation isn't just about laws– it's about people. Take Chilika Lake in Odisha: when local communities took charge of restoring the lake, fish catches improved, and siltation reduced. Traditional knowledge, passed down for generations, has helped wetlands survive alongside modern science.

Speaking of science, tiny organisms like diatoms act as nature's early warning system, signalling changes in water quality. At Loktak Lake, scientists use them to monitor the lake's ecological health. New-age tools like remote sensing and GIS help map and manage wetlands more effectively.

The future of wetlands lies in smart urban planning. In Chennai, the Pallikaranai Marsh is now part of the city's flood management system, proving that wetlands aren't just nature's leftovers– they're essential infrastructure.

The silent struggle of India's wetlands

Despite their importance, wetlands face numerous challenges that hinder their potential to contribute fully to the SDGs. Pollution remains a significant threat. Imagine walking by a lake that once teemed with fish and birds but now foams with toxic froth and catches fire. This isn't a scene from a dystopian movie– it's the reality of Bellandur Lake in Bengaluru, where industrial pollution has pushed nature to the brink. Similarly, Hussain Sagar Lake in Hyderabad is choking under untreated sewage, turning its once-thriving waters into a suffocating algae pool. But pollution isn't the only problem. Sambhar Lake in Rajasthan, famous for its flamingos, is losing its habitat to illegal salt mining, leading to tragic bird deaths. In Keoladeo National Park, water scarcity and habitat changes have declined bird populations. And in Wular Lake, climate change is throwing water cycles into chaos, threatening wildlife and local livelihoods.

Even when there are rules to protect wetlands, weak policies and governance issues get in the way. Take Najafgarh Wetland, where multiple government agencies argue over who's responsible, leaving the ecosystem unprotected. Worse still, many wetlands– like the seasonal wetlands of the Rann of Kachchh– remain understudied, making conservation efforts difficult.

Perhaps the biggest challenge is awareness. In Pichavaram Mangroves, people encroach upon fragile wetlands simply because they don't realise their importance. Without public support, conservation efforts often fall short.

Reflection prompt : *Think about a wetland near your city or village. What threats do you observe? How can local communities contribute to its conservation?*

Recommendations and the way forward

Imagine a world where wetlands are no longer disappearing but thriving– clean waters, rich biodiversity, and communities benefiting from their natural wealth.

A village pond with abundant aquatic plants, providing water purification, biodiversity support, groundwater recharge, and essential resources for local communities

A man-made lake inside a wildlife protected area, serving as a vital water source for wildlife while supporting endemic biodiversity and enhancing ecosystem resilience

That future is possible, but it requires action from all of us.

First, stronger laws and policies are needed. Wetland protection rules must be enforced, and these ecosystems should be woven into national climate action plans. After all, wetlands are not just water bodies; they are natural climate warriors!

Science and monitoring also play a crucial role. Long-term research can help track changes, and tiny organisms like algae can act as warning signals when water quality declines. The more we understand wetlands, the better we can protect them.

But conservation isn't just about policies and science– it's about people. Local communities have lived alongside wetlands for generations, relying on them for food, water, and livelihoods. Their traditional knowledge, like Loktak Lake's floating phumdi management, offers valuable lessons in sustainability. By involving them in conservation efforts, we turn them into wetland guardians. Mainstreaming wetlands into development planning is equally important. Cities, too, need wetlands. Urban wetlands should be part of flood management plans and smart city projects, helping prevent disasters while keeping nature intact. Pallikaranai Marsh in Chennai is an excellent example of how wetlands can be integrated into urban resilience strategies.

A polluted urban river with floating foam, highlighting the impacts of untreated waste water on aquatic ecosystems, public health, and biodiversity challenging SDG 6 (Clean Water and Sanitation), SDG 11 (Sustainable Cities and Communities), and SDG 14 (Life Below Water)

Bringing wetlands into SDG planning

To truly harness the power of wetlands, we need to prioritise them in global and national sustainability plans. Stronger policies and community-driven action are key to stopping wetland loss and ensuring their long-term health. But no one can do it alone- wetland conservation thrives on teamwork! Governments, scientists, communities, and industries must work together, especially at Ramsar Sites, to protect these ecosystems for future generations.

Future outlook: As we approach 2030, emerging technologies like AI-driven environmental monitoring, nature-based solutions, and eco-tourism models could redefine wetland conservation strategies in India. What can you do? Start by learning about a wetland near you. Join local conservation efforts, spread awareness, and advocate for policies that prioritise wetland health. Every action counts!

Saving wetlands, securing our future: A blueprint for achieving SDGs

Imagine a world where floods are less destructive, drinking water is cleaner, and the air carries less carbon

A village temple pond, serving as a sacred water body that supports biodiversity, groundwater recharge, and cultural traditions, aligning with SDG 6 (Clean Water and Sanitation) and SDG 15 (Life on Land)

A Myristica swamp, a unique freshwater swamp ecosystem dominated by ancient, evergreen trees, supporting endemic biodiversity, carbon sequestration, and hydrological balance, contributing to SDG 6 (Clean Water and Sanitation) and SDG 15 (Life on Land)

pollution. This isn't a distant dream– it's what wetlands do for us daily! But to keep enjoying these benefits, we must act.

What can we do

1. **Protect what's left:** Wetlands need stronger laws and better conservation efforts to stop them from vanishing. We must also reduce waste and manage resources wisely to ease the burden on these fragile ecosystems.
2. **Restore and revive:** Damaged wetlands can bounce back with the right care! Restoring degraded areas helps bring back lost biodiversity, giving wildlife a safe home while ensuring wetlands continue to provide clean water and climate protection.
3. **Fight pollution:** Pollution is choking our wetlands from plastic waste to toxic chemicals. Better waste management and sustainable practices can keep these ecosystems clean and thriving.

The good news? We don't have to do this alone! Governments, scientists, local communities, and industries must work together to protect these vital ecosystems. And perhaps the most powerful tool we have is awareness - educating people about the importance of wetlands can inspire collective action. By prioritising these strategies, we can safeguard wetlands, strengthen India's commitment to the Sustainable Development Goals (SDGs), and build a future where people and nature thrive.

Conclusion

Wetlands are more than just water bodies– they are the unsung heroes of our environment. They purify water, prevent floods, store carbon, and support millions of people and countless species. Yet, these ecosystems are disappearing at an alarming rate.As India moves toward 2030, protecting wetlands isn't just about saving nature– it's about securing our future. Their role in water security, climate resilience, and biodiversity conservation makes them essential for achieving the Sustainable Development Goals (SDGs). It is time to recognise wetlands as natural resources and nature's blueprint for a sustainable future.

Call to action: *How will you contribute to wetland conservation? Start by learning about the wetlands in your region and spreading awareness among your peers!*

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Commercialising Innovation: The Role of Technology Transfer Offices

Muthukumar P. and Jonas Davidson D.

Research institutions, such as universities and colleges, national research laboratories, and government agencies, are significant sources of new knowledge and discoveries. Traditionally, these entities have found it difficult to commercially exploit their discoveries due to lack of market access, manufacturing, and distribution means. In today's economy, there is a growing expectation for these institutions to contribute to economic growth and societal progress by translating their research into marketable products and services. This article aims to explore effective ways to translate research findings into marketable products or services, highlighting how this process helps research institutions to generate revenue and gain a competitive edge. It will thoroughly explain the crucial role of collaboration with industry partners, investors, and other stakeholders in turning research into profit and discuss ways for research institutions to unlock the full commercial potential of their innovations and drive economic growth through successful commercialisation of research findings via technology transfer and the building of strong business relationships.

Countries that prioritise research, development and innovation aren't just chasing the next big idea– they're building the foundation for lasting economic resilience and a higher quality of life. Innovation is a critical component of R&D, serving as a catalyst for economic growth. Innovation is far more than the creation of novel products– it's a powerful force that reshapes economies and redefines the future. At its core, innovation opens doors to entirely new markets, offering solutions and services that were once unimaginable. These breakthroughs pave the way for fresh consumer demands and previously untapped opportunities. At the same time, innovation breathes new life into existing markets. By improving or reinventing products, companies can appeal to broader audiences, enhance customer experiences, and carve out a larger share of the market. But perhaps the most transformative impact of innovation lies in its ability to spark the rise of entirely new industries. From the digital revolution to clean energy, history shows that disruptive ideas can reshape economic landscapes, create thousands of jobs, and attract massive investment. In this way, innovation isn't just a business strategy– it's an engine of growth and a cornerstone of long-term prosperity.

Research and innovation

Behind every breakthrough product or life-changing innovation lies a story of bold research. At the heart of technology transfer– the process of turning ideas into real–world solutions– is the groundbreaking scientific exploration. Research investment is a crucial indicator of a country's commitment to fostering innovation. While funding research doesn't instantly translate into economic miracles, it does spark the ideas and technologies that drive long-term progress. From cutting-edge medical treatments to smarter energy systems, R&D lays the foundation for new

Identification:
Evaluation
Protection
Negotiation
Implementation
Monitoring

tools, new industries, and a stronger society.

Simply put, research powers advancement. It's how we move from possibility to reality– and it's how tomorrow's technologies start taking shape today.

Multi-stage journey

Technology transfer is a complex process that involves the movement of knowledge, skills, and technologies from one entity to another. It typically consists of several stages, each with its own challenges and opportunities. Understanding these stages can help organisations navigate the technology transfer process more effectively.

- **Identification:** The first stage of technology transfer involves identifying the technology or knowledge that needs to be transferred. This may involve conducting research, assessing market needs, and evaluating the potential impact of the technology.
- **Evaluation:** Once a technology has been identified, it must be evaluated to determine its feasibility and potential value. This stage may involve assessing the technical, economic, and legal aspects of the technology.
- **Protection:** Intellectual property protection is a crucial aspect of technology transfer. This stage involves securing patents, copyrights, or other forms of protection to ensure that the technology remains confidential and proprietary.
- **Negotiation:** Negotiating technology transfer agreements is a key step in the process. This stage involves discussing terms, conditions, and responsibilities with the parties involved in the transfer.
- **Implementation:** Once an agreement has been reached, the technology transfer process moves into the implementation stage. This may involve training, support, and ongoing collaboration to ensure the successful transfer of the technology.
- **Monitoring:** Monitoring and evaluating the technology transfer process is crucial to confirm that it meets its objectives. This stage comprises tracking progress, identifying challenges, and making adjustments as needed.

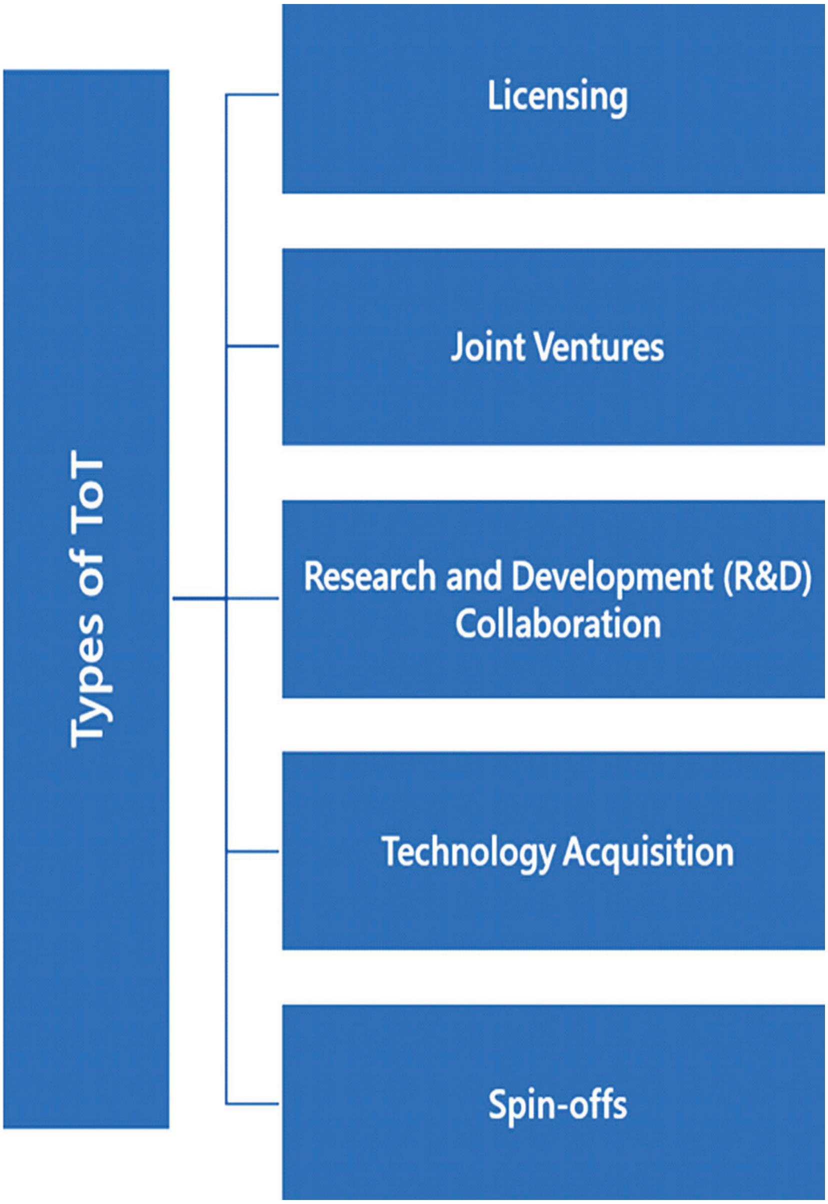
By understanding and effectively navigating these stages, organisations can successfully transfer technology and knowledge to drive innovation and growth.

Types of technology transfer

Technology transfer can occur in several forms, depending on the nature of the technology and the entities involved. The main types include:

- **Licensing:** In licensing agreements, a company grants another entity the right to use its technology, usually in exchange for royalties or other forms of compensation.
- **Joint ventures:** Joint ventures involve two or more companies coming together to collaborate on a project or develop a new technology. This type of technology transfer allows for shared resources and expertise.
- **Research and Development (R&D) collaboration:** R&D collaboration involves two or more entities working together to conduct research and develop new technologies. This type of technology transfer can lead to the creation of innovative products and solutions.
- **Technology acquisition:** Technology acquisition involves one company purchasing the technology or intellectual property rights of another company. This type of technology transfer allows for the rapid adoption of new technologies.
- **Spin-offs:** Spin-offs occur when a company creates a new entity to commercialise a specific technology or innovation. This type of technology transfer can help bring new technologies to market more quickly.

Each type of technology transfer has its own advantages and challenges, and research institutions must carefully consider which approach is



best suited to their specific needs and goals.

Challenges faced

- Translating research into marketable products or services can be a complex and challenging process. One of the main challenges is bridging the gap between the academic world, where research is conducted, and the business world, where products are developed and sold. Researchers may lack the business acumen and resources needed to bring their ideas to market, while business professionals may struggle to understand the technical aspects of the research.
- Another challenge is securing funding to support the commercialisation process. Research projects typically demand a substantial financial investment for developing prototypes, conducting market research, and scaling up production. Securing funding from investors or government grants can be a lengthy and competitive process.
- Additionally, navigating the regulatory landscape can be a major hurdle. Products developed from research often need to meet strict regulatory requirements before they can be brought to market. Ensuring compliance with regulations and obtaining necessary approvals can be a time-consuming and expensive process.
- Collaboration between researchers, business professionals, and other

Technology transfer offices

Behind every laboratory breakthrough that reaches the marketplace, there's often a technology transfer office (TTO) quietly making it happen. These offices play a crucial role in moving cutting-edge research out of the lab and into the hands of industries that can turn it into real-world solutions. TTOs act as the bridge between academia and the commercial world. They manage intellectual property, negotiate licensing deals, and build strategic partnerships between researchers and businesses. Their mission? To make sure that innovative discoveries don't just stay on paper but evolve into products, technologies, and services that benefit society. Beyond legal and business expertise, TTOs also offer hands-on support to researchers, navigating them through the often complex process of commercialisation. From patent filings to start-up development, they equip scientists and innovators with the tools to bring their ideas to life. In the bigger picture, TTOs are vital engines of innovation-driven growth, transforming academic research into economic opportunity and societal progress.

stakeholders is essential to successfully translate research into marketable products. Building strong partnerships and leveraging each other's expertise can help overcome the challenges and bring innovative ideas to market.

Unlocking the commercial potential

Technology transfer is a crucial process for unlocking the commercial potential of innovative ideas and research. It involves the transfer of technology from research institutions or universities to the commercial sector for further development and commercialisation. Here are some key strategies for successful technology transfer:

- **Establishing strong partnerships:** Collaborating with industry partners can help facilitate technology transfer by providing access to resources, expertise, and market insights.
- **Protecting intellectual property:** Securing patents and copyrights for innovative technologies is essential to protect intellectual property rights and attract potential investors.
- **Developing a clear commercialisation plan:** Creating a detailed plan outlining the steps for commercialising the technology can help streamline the transfer process and attract funding.
- **Building a strong entrepreneurial team:** Having a team with a mix of technical expertise and business acumen can help drive the commercialisation process forward.
- **Leveraging funding opportunities:** Exploring funding options such as grants, venture capital, and government programmes can provide the financial support needed to bring the technology to market.

By implementing these strategies, research institutions and universities can effectively transfer their technologies to the commercial sector and unlock their full commercial potential.

Competitive edge

The successful commercialisation of research findings, facilitated by effective technology transfer processes and strong relationships, directly contributes to economic growth and national competitiveness. Innovation, stemming from R&D, drives economic progress by creating new markets, industries, and fostering the growth of existing ones. By transforming scientific discoveries into products and services, research institutions contribute to job creation and ultimately improve the quality of life. For companies, accessing and commercialising technologies from research institutions offers a critical pathway to gaining a long-term competitive edge. This can involve licensing innovative products or processes, engaging in contract research to solve specific problems, or forming strategic partnerships for co-development. Leveraging the deep scientific knowledge and specialised facilities of research institutions allows companies to innovate faster, develop superior products, and compete more effectively in global markets. Technology exports, a measure of a country's ability to use its technological capabilities to compete internationally, are positively linked to economic growth. Successful technology transfer from institutions to companies directly contributes to this capability. Furthermore, the revenue generated from successful commercialisation can be reinvested by institutions to support further research and educational missions, creating a virtuous cycle of discovery, innovation, and economic impact.

Conclusion

Research institutions are uniquely positioned to fuel economic growth by transforming groundbreaking discoveries into market-ready innovations. But this transformation doesn't happen automatically and rather requires a deliberate, strategic approach that reaches far beyond the lab bench. At the heart of this journey is the technology transfer office (TTO), which has evolved into a central hub overseeing a complex ecosystem of intellectual property protection, technology development, entrepreneurial support, and relationship management. To unlock the full commercial value of research, institutions must go further– by strengthening IP frameworks, investing in translational research to overcome the 'valley of death', fostering strong ties with industry and investors, nurturing a dynamic start-up culture, building skilled TTO workforce, and securing long-term fundingand most importantly proactively addressing cultural and systemic barriers. Collaboration isn't optional– it's essential. Partnerships with industry, government, investors, and peer institutions provide the expertise, capital, and market access necessary to turn promising research into profitable, scalable solutions. When research institutions embrace this interconnected model, they don't just commercialise inventions– they shape industries, create jobs, and elevate national competitiveness. Ultimately, viewing technology transfer not as a one-time transaction but as a long-term investment in innovation is the key to unlocking sustainable economic impact– both at the national and global platform.

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Generate Wealth from Plastic Waste

PLASTIC WASTE MANAGEMENT IS A HUGE CHALLENGE FOR THE SOCIETY. WE CAN SOLVE IT TOGETHER.

A Technology for Manufacturing of Graphene from Waste Plastic

APPLICATIONS: Water Treatment; Battery and Super Capacitors; Flexible LED Displays; Concrete; Paints; Fuel Cells; Solar Cells; Wind Turbines, and many more...

This technology is available for licensing through NRDC.

This first of its kind innovation, not only reduces the footprints of waste plastics, but also fully accomplishes three main priorities of our country. namely 'Clean India Mission', 'Waste-to-Wealth' and 'Waste-to-Energy'.

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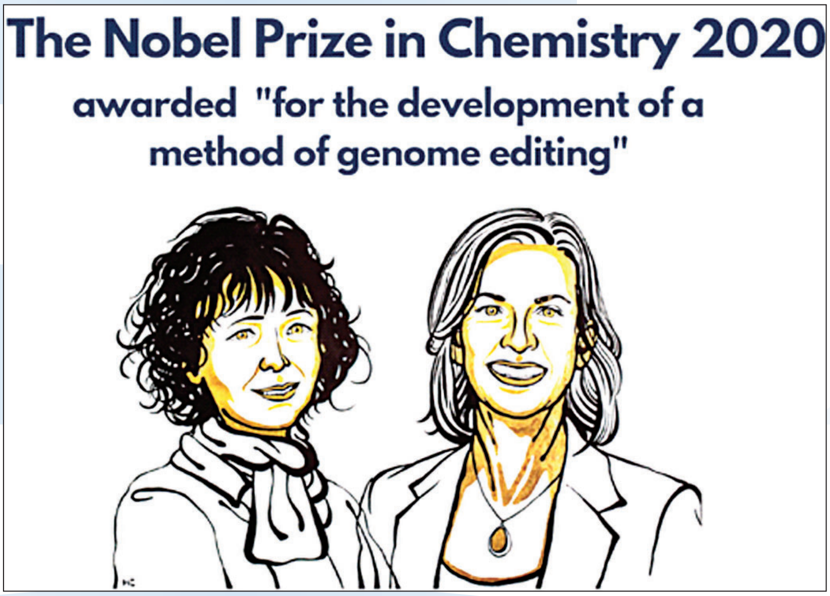
The Spurt of Innovations in Biotechnology: Pushing Fiction Closer to Reality

Deo Prakash Chaturvedi

We are living in an era defined not merely by digital transformation or space exploration, but by a revolution in our understanding and manipulation of life itself. The 21st century has ushered in a new biological age - one where the building blocks of life, once hidden in the double helix of DNA, are now readable, editable, and increasingly engineerable. The consequences of this transformation are profound and far-reaching. Modern biotechnology spans a remarkable range of innovations, from genome editing and synthetic life to organ regeneration and personalised medicine. What sets this revolution apart from previous ones driven by physics, chemistry, or engineering is its intimate engagement with life's most fundamental processes. It does not merely enhance or mimic life– it actively rewrites it. Genes can be silenced or enhanced; microbes can be designed to digest plastic or produce insulin; cells can be coaxed into growing miniature organs in a dish. The line between science fiction and reality is blurring at a rapid pace.

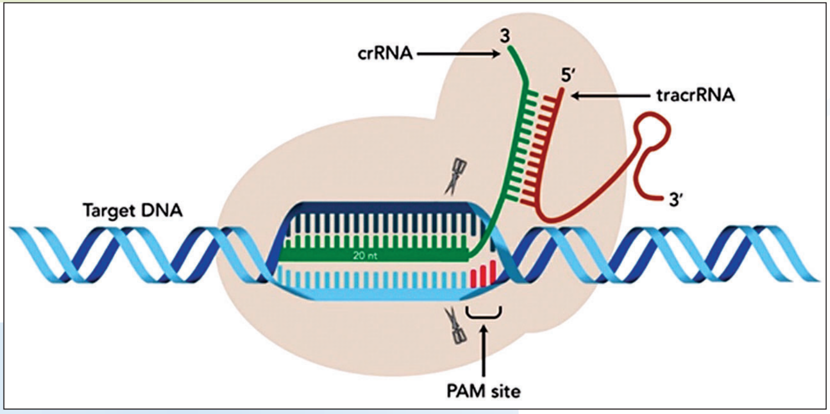

The Nobel Prize in Chemistry 2020
awarded "for the development of a method of genome editing"

Dr. Emmanuelle Charpentier and Dr. Jennifer Doudna were awarded the 2020 Nobel Prize in Chemistry for their pioneering work in developing the CRISPR-Cas9 genome editing technology

Biotechnology's impacts are as varied as they are vast. In medicine, new treatments target cancer cells with surgical precision. In agriculture, crops are now being tailored to withstand climate change and pests without the baggage of traditional genetic modification. In environmental science, microbial ecosystems are being repurposed to clean up pollutants and preserve biodiversity. As the boundaries between biology, technology, and society continue to dissolve, the need to understand and engage with these changes becomes increasingly urgent. The following pages describe five of the most transformative biotechnological innovations of the 21st century.

CRISPR-Cas9

In 2012, a scientific breakthrough quietly transformed the world of genetics. Scientists Jennifer Doudna from the University of California, Berkeley, and Emmanuelle Charpentier from the Max Planck Institute published a paper describing a powerful new tool– CRISPR-Cas9. Just eight years later, in 2020, the duo was awarded the Nobel Prize in Chemistry for their discovery. Their work was not only revolutionary in terms of scientific progress– it fundamentally changed how we think about altering life itself. CRISPR stands for 'Clustered Regularly Interspaced Short Palindromic Repeats', which are part of a natural immune system found in bacteria. These microbes use CRISPR to remember and fight off viruses by cutting their DNA. Scientists realised



CRISPR-Cas9 system attached to a target DNA sequence (Image source: IDT DNA)

that this system could be adapted as a precise tool to edit the genes of any organism - including humans. With the help of guide RNA, the Cas9 protein in the CRISPR system – functioning like molecular scissors – can be directed to a specific gene with a nearby protospacer adjacent motif (PAM) sequence, where it introduces a precise cut. The cell then repairs the cut, often resulting in changes to the gene– either turning it off, modifying it, or replacing it with something new. What makes CRISPR-Cas9 revolutionary is its simplicity, affordability, and accuracy compared to older genetic engineering techniques. It allows researchers to change the genetic code almost as easily as editing a document on a computer. This has opened doors to correcting genetic diseases, enhancing agricultural crops, and even combating viral infections.

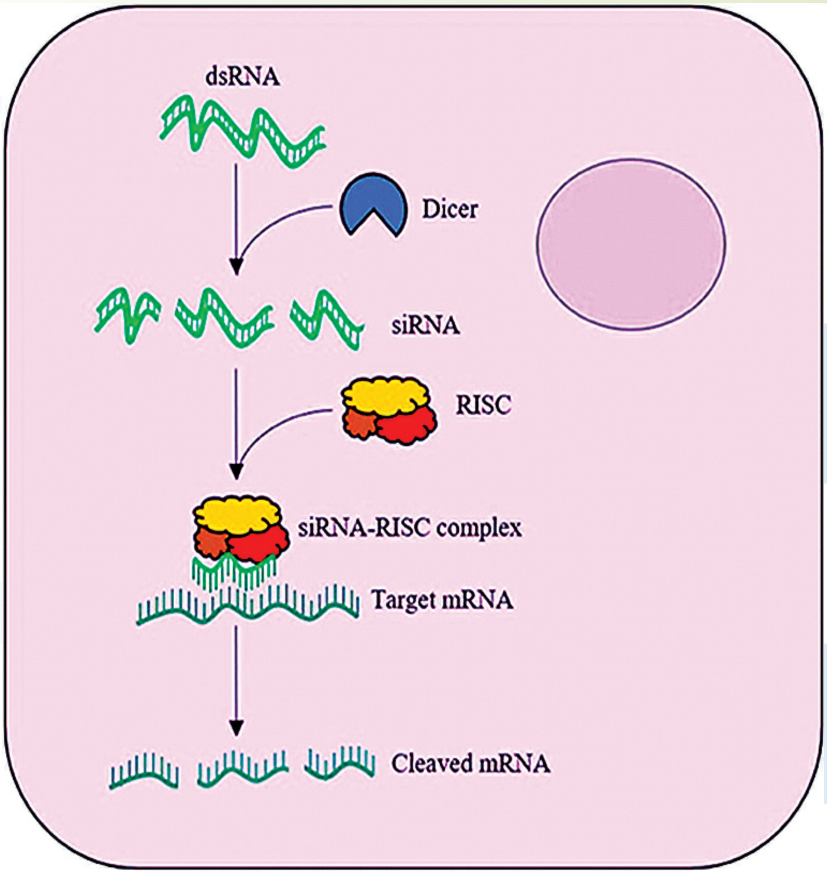
In the medical field, CRISPR is already showing results. Experimental therapies are being used to treat genetic conditions like sickle cell anaemia, beta-thalassemia, and hereditary blindness. In 2020, a woman in the United States, Victoria Gray, became the first person to be treated for sickle cell disease using CRISPR technology, with promising outcomes. There are also ongoing trials for cancers, including leukemia and lymphoma. Agriculture, too, is undergoing a quiet revolution. Scientists have used CRISPR to develop crops that are more resistant to pests, diseases, and extreme weather. Unlike traditional GMOs that involve transferring genes from one species to another, CRISPR allows for precise, within-species edits. This makes it potentially more acceptable to consumers and regulators. India has become an active participant in the global CRISPR movement. During the COVID-19 pandemic, researchers at the Institute of Genomics and Integrative Biology (IGIB) in Delhi developed a CRISPR-based diagnostic tool called FELUDA (named after the fictional detective created by Satyajit Ray). This rapid test was affordable, effective, and entirely made in India. Meanwhile, agricultural scientists at institutions like the Indian Agricultural Research Institute (IARI) are using CRISPR to improve staple crops such as rice and wheat, making them more resilient to climate change.

Dr. Andrew Fire and Dr. Craig Mello were awarded the 2006 Nobel Prize in Physiology or Medicine for their discovery of RNAi

However, as with any powerful technology, CRISPR also comes with serious ethical and societal challenges. The most controversial application is 'germline editing' - changing the DNA of embryos so that the changes are inherited by future generations. In 2018, a Chinese scientist, He Jiankui, claimed to have created the world's first gene-edited babies by modifying embryos to be resistant to HIV. The international backlash was swift and severe. Most scientists and ethicists condemned the move as premature, unethical, and dangerous.

RNA Interference (RNAi)

Imagine being able to switch off a gene - not permanently deleting it, but simply putting it on mute. That is, in



RNAi mechanism (Image source: Pugsley et al., 2021)

essence, what RNA interference, or RNAi, allows scientists to do. Unlike technologies that edit the DNA itself, RNAi works one step downstream in the gene expression process, targeting messenger RNA (mRNA) molecules before they can produce proteins. This elegant system has become one of the most powerful tools in modern biology, revolutionising everything from medicine to agriculture. The discovery of RNAi was awarded the Nobel Prize in Physiology or Medicine in 2006, just a few years after its potential became clear. The prize went to Andrew Fire and Craig Mello, who published a landmark paper in 1998 showing how small strands of RNA could be used to silence specific genes in the nematode worm Caenorhabditis elegans.

In cells, DNA is first transcribed into mRNA, which carries the instructions to build proteins. These proteins then go on to carry out nearly all cellular functions. RNA interference interrupts this process. It uses small pieces of RNA - like small interfering RNA (siRNA) or micro-RNA (miRNA) - to bind to specific messenger RNA (mRNA) molecules, leading either to their destruction by the RISC complex or to the blocking of their translation into protein. The result is a significant reduction in the corresponding protein, without altering the underlying DNA. In medicine, this has created a whole new class of drugs that target diseases at the genetic level. The first RNAi-based therapy approved by the U.S. Food and Drug Administration (FDA) was Onpattro (patisiran) in 2018. Onpattro treats a rare but deadly condition called hereditary transthyretin-mediated amyloidosis, which causes a buildup of abnormal protein in the nerves and organs. By silencing the gene responsible for producing the faulty protein, the drug offers relief to patients for whom there was previously no effective treatment.

The promise of RNAi extends far beyond human health. In agriculture, it has emerged as a potent alternative to conventional genetic modification. Indian scientists have been at the forefront of this effort. At institutions like the Indian Agricultural Research Institute (IARI), National Institute of Plant Genome Research (NIPGR), etc. researchers have developed RNAi-based pest-resistant plants like cotton. This technology, in cotton, specifically targets the bollworm – a pest responsible for massive crop losses – by silencing essential genes in the insect's gut, leading to its death when it feeds on the plant.

However, RNAi is not without its challenges and concerns. One of the main scientific questions is off-target effects - what happens if the small RNA silences a gene other than the one it was intended for? Since many genes share similar sequences, unintended silencing can have unpredictable biological consequences. This is especially critical in medical applications, where side effects can be dangerous. There are also environmental considerations. If RNAi-based crops become widespread, how will they affect non-target organisms, such as beneficial insects or soil microbes? Could pests evolve resistance to RNAi in the same way they have to chemical pesticides? These questions require thorough, ongoing research and rigorous regulatory oversight.

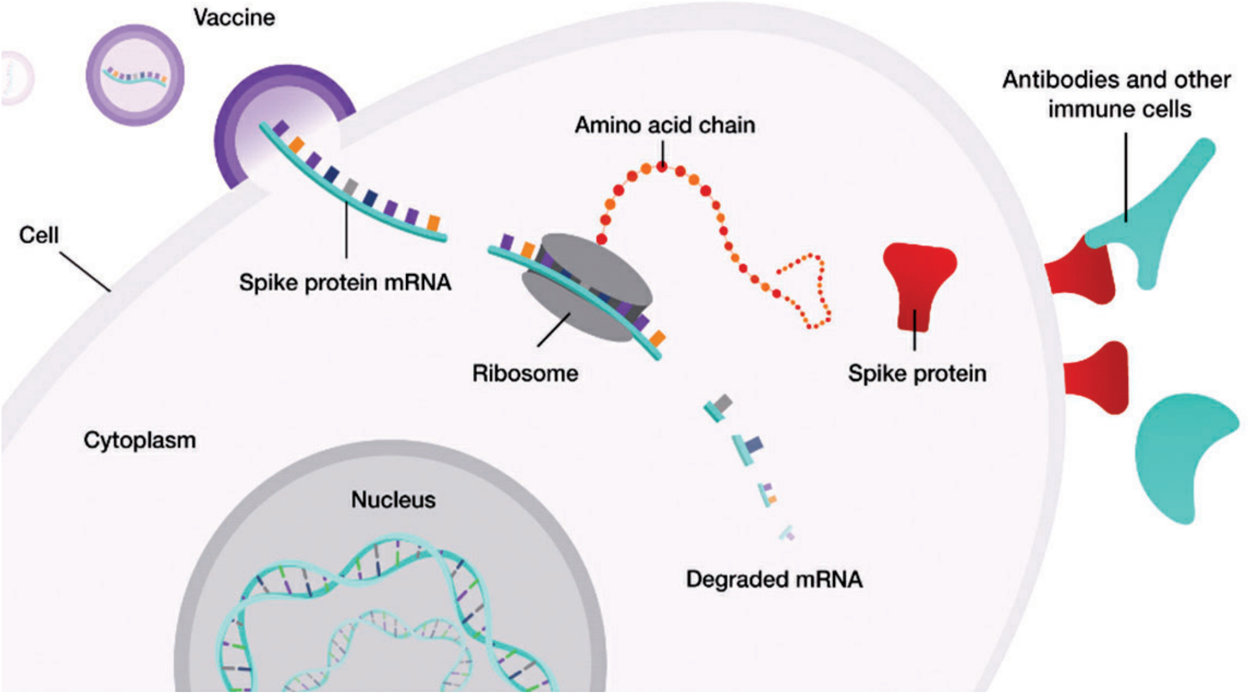


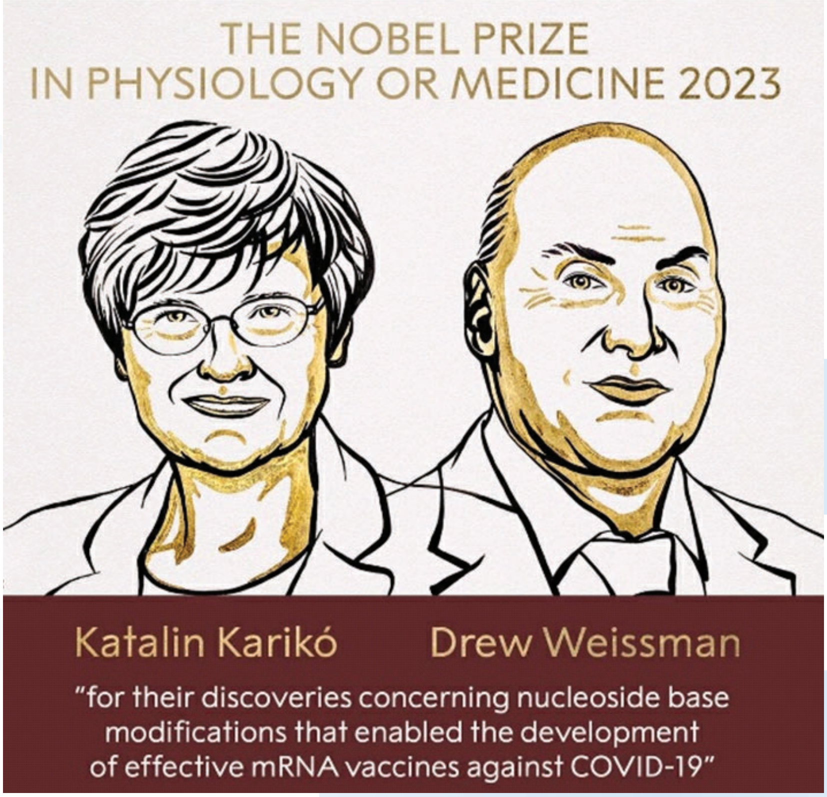
Image showing schematics of the Covid-19 mRNA vaccine (Image source: genome.gov)

The mRNA vaccines

Vaccines have long been among humanity's most effective tools in combating disease. From smallpox to polio, they've saved millions of lives by training the immune system to recognise and neutralise dangerous pathogens. But for over a century, the way vaccines were made remained largely unchanged– using weakened or inactivated viruses, or fragments of viral proteins. That paradigm shifted dramatically in 2020, with the global rollout of the first messenger RNA (mRNA) vaccines during the COVID-19 pandemic. mRNA vaccines do not contain any part of the actual virus. Instead, they use a genetic blueprint - messenger RNA - that instructs our own cells to produce a harmless version of a virus-specific protein. In the case of COVID-19, that protein was the spike protein found on the surface of the *SARS-CoV-2* virus. Once the protein is made, the body's immune system detects it as foreign and begins building defences - antibodies and T-cells - that prepare the body to fight off the real virus if it ever arrives.

This approach is revolutionary for several reasons. First, it's incredibly fast. Traditional vaccine development can take years or even decades because it often requires growing live viruses in eggs or cell cultures. mRNA vaccines, by contrast, are built using synthesised genetic sequences, allowing them to be designed and manufactured rapidly. When the genetic code of the novel coronavirus was published in early January 2020, scientists at companies like Moderna and BioNTech (partnering with Pfizer) began designing mRNA vaccine candidates almost immediately. Just 11 months later, the Pfizer-BioNTech and Moderna vaccines became the first mRNA vaccines to receive emergency use authorisation, a timeline previously unimaginable.

The science behind mRNA vaccines is not new, though it had long been seen as too unstable for practical use. Key breakthroughs came in the 2000s, thanks in part to Hungarian-born scientist Katalin Karikó and immunologist Drew Weissman, whose decades of research at the University of Pennsylvania uncovered ways to modify mRNA molecules to reduce inflammation and improve stability. Their foundational work allowed mRNA to be delivered safely into human cells– an achievement that earned them the 2023 Nobel Prize in Physiology or Medicine. India, though initially behind in the mRNA race, has begun carving out its own path. Gennova Biopharmaceuticals, a Pune-based company, developed India's first indigenous mRNA vaccine candidate, called HGCO-19. Created with support from the Department of Biotechnology under the Government of India, HGCO-19 underwent clinical trials starting in 2021. While it did not reach the market as quickly as Pfizer or


THE NOBEL PRIZE
IN PHYSIOLOGY OR MEDICINE 2023
Katalin Karikó
Drew Weissman
"for their discoveries concerning nucleoside base modifications that enabled the development of effective mRNA vaccines against COVID-19"

Dr. Katalin Karikó and Dr. Drew Weissman were awarded the 2023 Nobel Prize in Physiology or Medicine for their pioneering research on mRNA technology

Moderna's offerings, it marked a critical leap forward for domestic biotech innovation. However, mRNA vaccines also face key challenges, particularly in storage and distribution. Early versions required ultra-cold temperatures (as low as -70°C), making delivery difficult in many parts of the world.

Induced Pluripotent Stem Cells

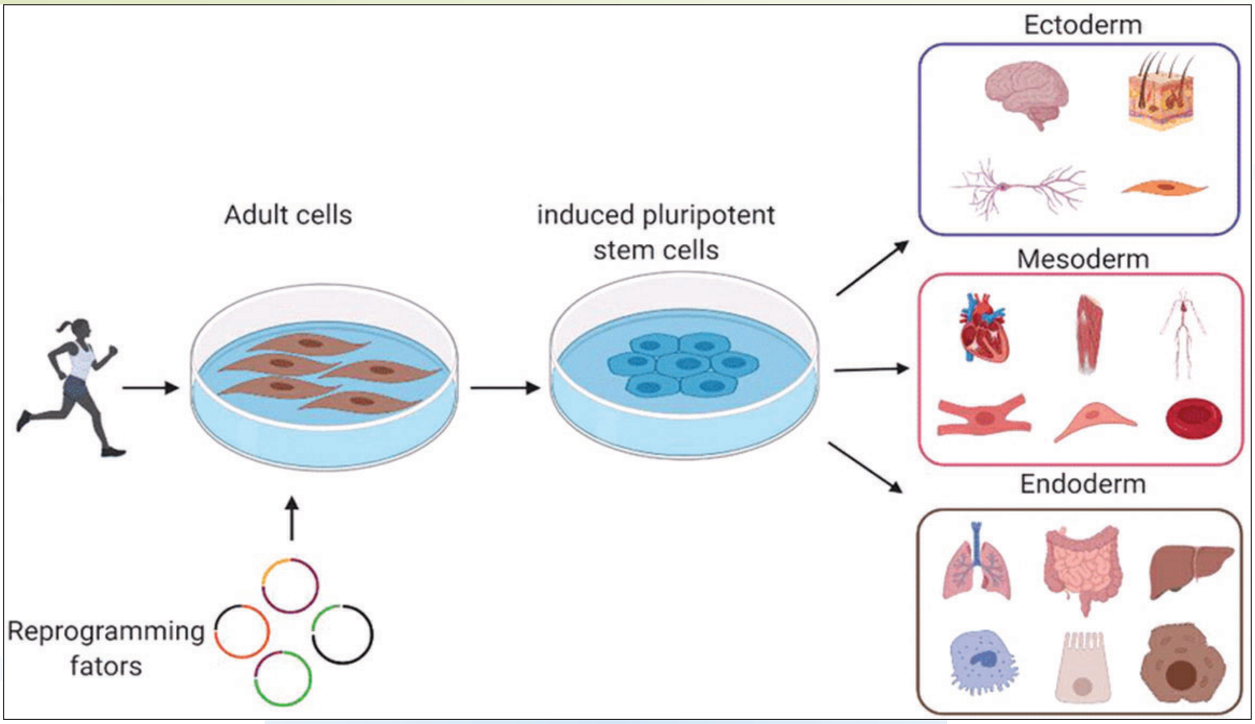
Induced Pluripotent Stem Cells (iPSCs) are a type of stem cell created by reprogramming mature, specialised cells – like skin or blood cells – back into an embryonic-like pluripotent state. This means they regain the ability to develop into almost any type of cell in the body, similar to embryonic stem cells (ESCs), but without the ethical concerns associated with harvesting cells from embryos. The technology was pioneered in 2006 by Japanese scientist Dr. Shinya Yamanaka and his team, who identified four key genes - Oct3/4, Sox2, Klf4, and c-Myc - that, when introduced into adult mouse fibroblast cells, could 'reprogram' them into pluripotent stem cells. A year later, they replicated this success in human cells. For this ground-breaking discovery, Dr. Yamanaka was jointly awarded the 2012 Nobel Prize in Physiology or Medicine along with Sir John B. Gurdon, who had earlier demonstrated the reversibility of cell differentiation through nuclear transfer in frogs. iPSC technology holds immense promise across many areas of science and medicine. It allows for the generation of patient-specific stem cells without the need for embryos, enabling personalised medicine, disease modelling, and drug screening. For example, iPSCs derived from patients with genetic disorders such as Parkinson's, Huntington's disease, or ALS can be used to create nerve cells in the lab, offering researchers a powerful way to study disease mechanisms and test new therapies. iPSCs are also being used in early-stage regenerative medicine.

Researchers are investigating their use in treating conditions such as macular degeneration, spinal cord injuries, heart failure, and diabetes. Clinical trials have already begun in some cases - for example, using iPSC-derived retinal cells to treat age-related blindness. Moreover, because these cells can theoretically be generated from a patient's own tissues, they reduce the risk of immune rejection in future transplantation therapies.

CAR-T cell therapy

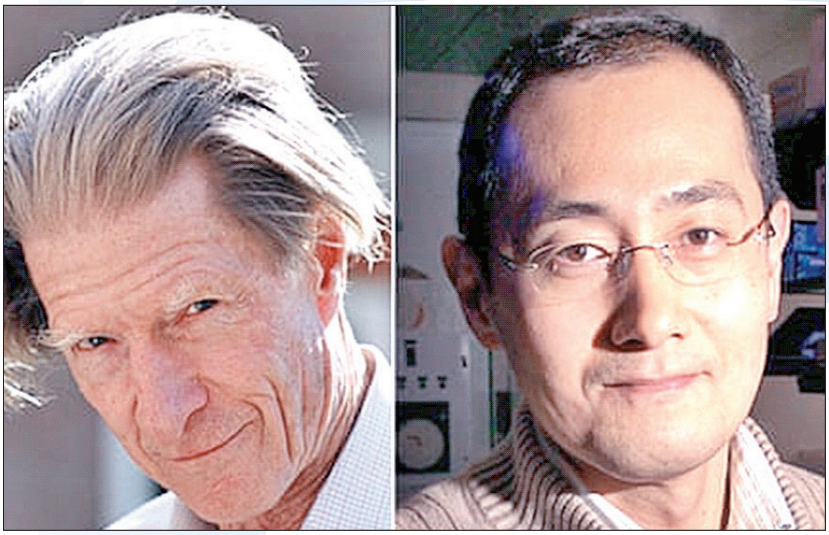
In the battle against cancer, few breakthroughs have generated as much hope - and excitement - as CAR-T cell therapy. Short for Chimeric Antigen Receptor T-cell therapy, this innovation represents one of the most advanced forms of personalised medicine in the modern era. Instead of using drugs or radiation to kill cancer cells, CAR-T therapy turns the patient's own immune system into a weapon. The idea is deceptively simple but scientifically brilliant: extract the patient's T cells (a type of white blood cell that normally attacks infected or abnormal cells), genetically modify them in the lab to recognise cancer, and infuse them back into the patient, where they act like guided missiles, hunting and destroying tumour cells with remarkable precision.

The breakthrough emerged from decades of research into immunology



Schematics of iPSC (Image source: Delsing et al., 2020)

and genetic engineering. The first major success came in the early 2010s, when researchers at the University of Pennsylvania, including Carl June, pioneered the first clinical trials of CAR-T therapy in leukemia patients. The results were astonishing– patients who had exhausted all other treatment options saw their cancers vanish. In 2017, the U.S. FDA approved the first CAR-T therapies: Kymriah (tisagenlecleucel) for childhood acute lymphoblastic leukemia; and Yescarta (axicabtagene ciloleucel) for adult lymphomas. Since then, CAR-T therapies have expanded rapidly. They are now being tested and used for multiple types of blood cancers, including multiple myeloma and chronic lymphocytic leukemia. Researchers are also exploring their use against solid tumours like lung, breast, and pancreatic cancer, although these remain more challenging due to the tumour microenvironment and immune evasion mechanisms.



Dr. Shinya Yamanaka was awarded the 2012 Nobel Prize in Physiology or Medicine, shared with Sir John B. Gurdon, for the discovery that mature, specialised cells can be reprogrammed to become iPSCs

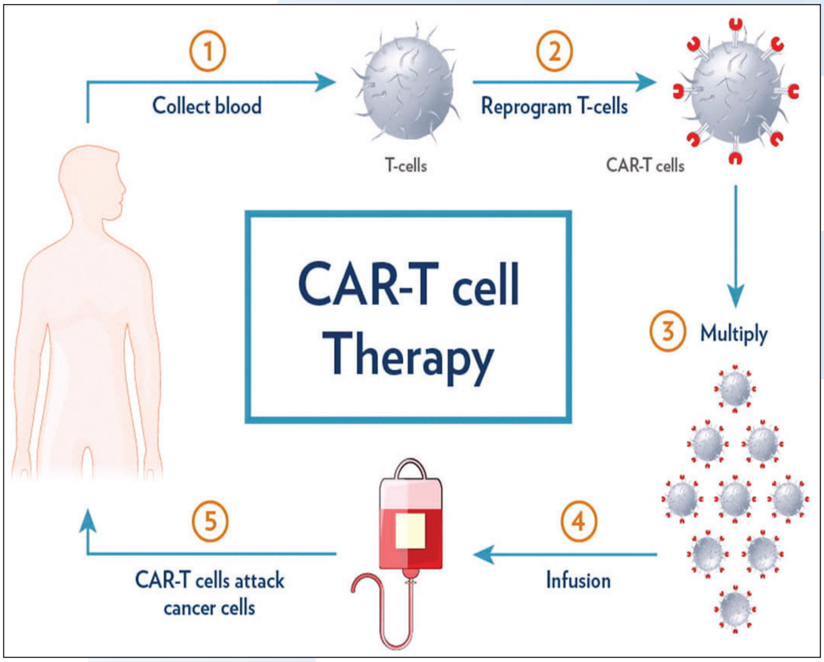
India marked a significant milestone in this global journey in 2023, when scientists at the Tata Memorial Centre (TMC) and IIT Bombay, supported by the Department of Biotechnology (DBT), and ImmunoACT, a spin-off company of IIT Bombay, announced the successful completion of India's first indigenous CAR-T therapy, NexCAR19, clinical trials. What made this achievement even more notable was the cost: while CAR-T therapy in the U.S. can cost upwards of ₹3-4 crore (around $400,000-$500,000), the Indian version was projected to be 10 to 20 times cheaper, bringing cutting-edge cancer care closer to affordability for

ImmunoACT
टी एम सी
TMC
सी ए आर - टी सेल थेरेपी राष्ट्र को समर्पण
Dedication of first indigenous CAR-T Cell Therapy to the Nation
by

Launch of NexCAR19 by Hon'ble President of India (Image source: PIB)

low- and middle-income populations.

However, CAR-T therapy is not without risks or limitations. When the modified T cells flood the body and attack cancer cells, they can also trigger a massive immune response called cytokine release syndrome (CRS). This can lead to fever, low blood pressure, organ dysfunction, and in rare cases, death. Patients often require intensive care support during the early stages of treatment. Another challenge is the complexity of manufacturing and delivering CAR-T therapy. The entire process– from collecting a patient's T cells, modifying them in a laboratory, expanding them, and infusing them back– can take weeks and requires sophisticated bioprocessing infrastructure. This has limited its availability to a few specialised centres, mostly in wealthy nations. Efforts are underway worldwide to simplify and scale up CAR-T therapy. Researchers are experimenting with 'off-the-shelf' CAR-T products, made from donor cells that can be stored and used as needed. This could revolutionise accessibility by transforming CAR-T from a bespoke, individualised treatment into a more widely deployable platform. Beyond cancer, CAR-T is being investigated for autoimmune diseases such as lupus and multiple sclerosis, where reprogramming the immune system could halt disease progression.


① Collect blood
T-cells
② Reprogram T-cells
CAR-T cells
③ Multiply
④ Infusion
⑤ CAR-T cells attack cancer cells
CAR-T cell Therapy

Schematics of CAR-T cell therapy (Image source: hollingscancercenter.musc.edu)

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Vitamin D Deficiency in India: A Silent Pandemic

Devina Kanoujia and Charu Lata

Vitamin D deficiency is a silent health emergency in India and prevails across all ages, ethnicities and regions. It is almost paradoxical, considering that India is a nation that enjoys widespread sunshine throughout the year. However, research indicates that one in every five Indian suffers from low vitamin D levels; in fact, in some urban areas, it stands at an alarming 89 per cent. This implies close to nine out of every 10 individuals in certain cities are not receiving this vital nutrient sufficiently. The deficiency has such a wide prevalence that experts call it a 'silent pandemic'. The worrisome aspect of this issue is that vitamin D deficiency is not always conspicuous. The deficiency may go unnoticed until their health is at risk, making it a quiet but dangerous threat to overall well-being.

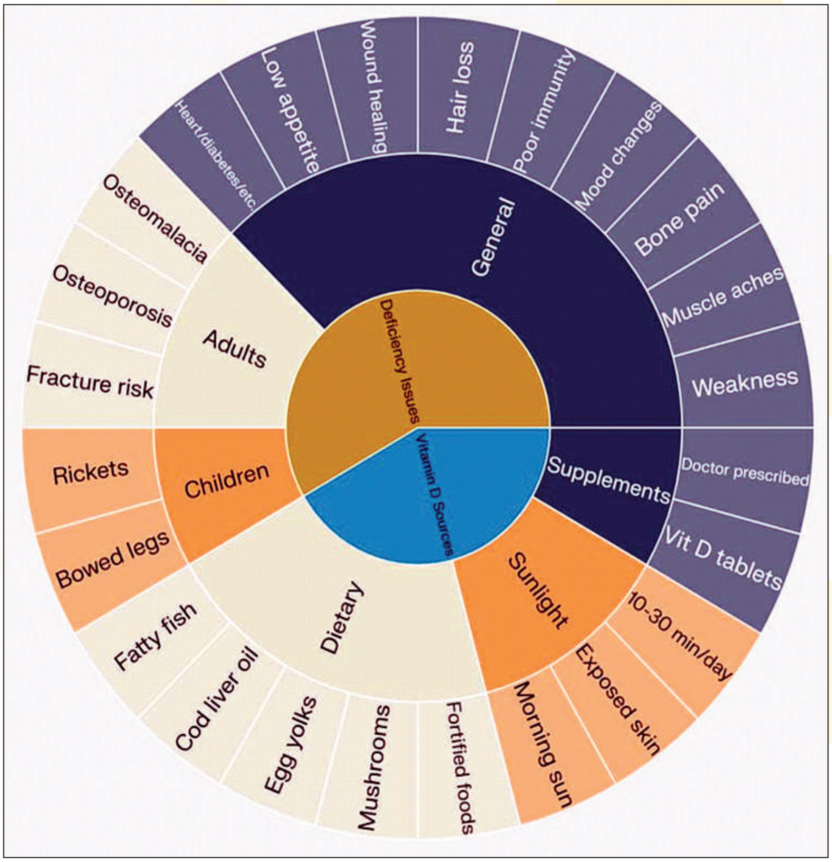
Vitamin D is often referred to as the 'sunshine vitamin' because our bodies can make it when our skin is exposed to sunlight. Specifically, the ultraviolet B (UVB) rays from the sun trigger the production of vitamin D in the skin. This vitamin is crucial for our health. It helps our bodies absorb calcium and phosphorus. These minerals are essential for building and maintaining strong bones and teeth. Without enough vitamin D, bones can become weak, brittle, or deformed. However, vitamin D does much more than just support bone health. It is rather important for a strong immune system, helps muscles function optimally, and even plays a role in keeping our mood stable. In other words, vitamin D is key to keeping us healthy, active and happy.

So, why is vitamin D deficiency so common in India, a country with so much sunshine? The answer lies in modern lifestyles, cultural practices, and environmental factors. First, many people in cities spend most of their time indoors, working in offices, studying in classrooms, or relaxing at home.

Tall skyscrapers, congested urban areas, and smog prevent sunlight from penetrating the ground, making it difficult for individuals to achieve adequate sun exposure. The widespread application of sunscreen, although vital in preventing skin damage from damaging rays, also prevents the UVB rays used for vitamin D synthesis. Cultural dress covers most of the body, particularly for females, and restricts exposed skin to the sun. Research has indicated that women who dress in clothes covering arms and legs are more likely to be vitamin D deficient than those who dress in clothes exposing more skin.

Skin colour is another significant factor. Individuals with darker skin tones, like most Indians, contain higher amounts of melanin, which protects them as a natural sunscreen. Although this guards against sunburn, it is also the case that their skin requires more sunlight to synthesise the same level of vitamin D as someone with lighter skin. To add to this, Indian diets, particularly vegetarian diets, tend to exclude foods that contain a lot of vitamin D. Most natural sources of vitamin D are animal products, like fatty fish and egg yolks, which are not often consumed in many Indian families. Because of this, even individuals with sun exposure might not be acquiring sufficient vitamin D from their diet.

The signs of vitamin D deficiency are subtle and can occur over a long period. Most individuals might not know they have an issue until serious health complications occur. Some of the most prevalent symptoms are chronic bone and muscle aches, particularly in the hips, lower back, and legs. Individuals can feel weak, experience difficulty climbing steps,



Vitamin D : Its sources and issues caused by its deficiency

or struggle to stand up from a sitting position. Tiredness and fatigue are also present, even after a night's rest. Low levels of vitamin D have also been associated with depression and mood changes so that individuals may be irritable or sad without any apparent reason. Repeated illnesses, particularly respiratory infections such as the flu and the common cold, may indicate that the immune system is not functioning optimally. Loss of appetite, thinning of hair, and delayed healing of cuts are other symptoms.

The effects of vitamin D deficiency extend well beyond mere aches and pains. In children, it can lead to rickets, when bones soften and weaken, resulting in bowed legs and other skeletal deformities. In adults and older adults, it leads to osteomalacia (soft bones) or osteoporosis (brittle bones), heightening the risk for fractures. Nevertheless, the consequences do not end there at the bone level. Studies have found that individuals with low vitamin D levels are at greater risk for a variety of chronic diseases, such as heart disease, type-2 diabetes, and some cancers, like breast and prostate cancer. Vitamin D deficiency has also been implicated in infertility, polycystic ovarian syndrome (PCOS), and neurodegenerative disorders like dementia and Alzheimer's disease. The immune system is compromised, with individuals being more susceptible to infections. Mental status is also compromised, with increased depression and cognitive impairment observed in individuals with low vitamin D. The issue is alarming among young Indians, with research indicating that over 80 per cent of individuals aged under 40 lack adequate vitamin D levels. This endangers not just personal well-being but also the future productivity and health of the entire country.

Considering the gravity of the situation, it is necessary to be aware of how to obtain sufficient vitamin D. The most effective and natural source is sunlight. Experts advise spending 10 to 30 minutes daily in the sun, which is best during the morning hours between 7 and 10 AM when the sun's rays are sufficient to produce vitamin D without being too intense to induce sunburn. Exposing the arms, legs, and face to the direct sun without sunscreen is the best way. However, diet and supplements can assist in making up for the loss.

Regarding nutrition, not many foods are good sources of vitamin D. Fatty fish such as salmon, sardines, and mackerel are some of the richest sources available. A mere 100 grams of salmon contains over 500 units of vitamin D, more than the average person requires in a day. Cod liver oil is another valuable source, with one teaspoon giving nearly the whole daily amount, even though its pungent taste may be off-putting to some. Egg yolks increase modestly, and adding eggs to the diet can be beneficial. For vegetarians, mushrooms that have been sun-exposed or put under UV light are the only source of high amounts of vitamin D in plants. Most dairy foods, such as soy milk, orange juice, and breakfast cereals, are now vitamin D fortified in India, so it is easy to obtain enough of this substance even if you do not consume animal foods. However, remember that these foods are more easily available in urban markets, and individuals in rural communities might have less access.

Supplements are also an option, particularly for individuals with a high risk of deficiency or those who have been found to have low vitamin D. It is wise to consult a physician before taking supplements since the appropriate dose will vary with the individual's needs and health status. Vitamin D absorption from supplements can be variable. Therefore, routine blood testing is advised to monitor and control vitamin D status, particularly in the case of symptoms or high-risk individuals.

Both solving and addressing the issue of vitamin D deficiency in India need intervention at numerous governmental, community, and individual levels. On an individual basis, individuals can incorporate minor modifications to their daily lives to enhance sun exposure, like walking in the morning, having breakfast outside, or getting children to play in the sun. Families can incorporate foods rich in vitamin D into their diet and use fortified products whenever available. Supplements, for those who require them, can be a safe and efficient means of increasing vitamin D levels, but only under the guidance of a medical professional.

Individuals and policymakers also have a role. Educational public health campaigns are necessary to inform the public about the necessity of vitamin D, the signs of deficiency, and prevention measures. Food processors must be urged to enrich widely eaten foods such as milk, oil, and breakfast cereals with Vitamin D. Schools can incorporate fortified foods in their meals so that kids receive sufficient vitamin D. Urban designers can create public places with activities promoting outdoor recreation and safe exposure to sunlight, including parks, playgrounds, and walking trails. Workplaces can offer outdoor breaks and even paid supplements for workers who spend much of their day indoors. Schools should provide children with enough sunlight time during school hours and incorporate vitamin D education in health classes.

Deficiency of Vitamin D is the most ignored deficiency after Vitamin B12 and Vitamin K. It is affecting tens of millions in India and leads to everything from compromised bone health to severe chronic illnesses. The good news is that most people find solutions that are within reach, practical, and straightforward. Adequate sun exposure, proper dietary habits, fortified food consumption, and regular intake of supplements can solve the issue.

We need to understand the significance of vitamin D and take action, both as individuals and as a society, so that we can enjoy better immunity, stronger bones, and a far healthier future. It is time to embrace sunshine and combine our efforts to eradicate vitamin D deficiency. The sunshine is free, and with an appropriate awareness programme and effort, we can all harness its life-giving energy to ourselves and our future generations.

Suggested Reading

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CSIR @ 84: Powering India through Science and Innovation

Dr. Manish Mohan Gore

The Council of Scientific and Industrial Research (CSIR), established in 1942, has completed 84 remarkable years of service to the nation, standing as one of India's premier scientific research organisations. It is a dynamic network of 37 National Laboratories, 39 Outreach Centres, one Innovation Complex and three Units. Since its inception, CSIR has been at the forefront of advancing science, technology, and innovation for the nation's growth and development. With a vast network of laboratories, research centres, and dedicated scientists, CSIR has made pioneering contributions in diverse fields such as oceanography, earth sciences, geophysics, chemicals, drugs, genomics, biotechnology and nanotechnology to mining, aeronautics, instrumentation, environmental engineering and information technology. It provides significant technological intervention in many areas with regard to societal efforts, which include environment, health, drinking water, food, housing, energy, leather, farm and non-farm sectors.

Anusandhan Bhawan: CSIR headquarters at New Delhi

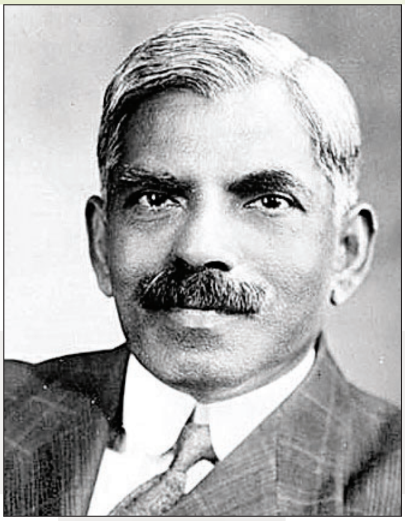
Over the decades, CSIR has played a vital role in strengthening India's self-reliance by developing indigenous technologies and transferring them to industries, thereby fuelling industrial growth and supporting the economy. From producing life-saving drugs at affordable costs to innovating in green technologies, CSIR's initiatives have touched the lives of millions of people. It has also contributed significantly to national missions like climate change mitigation, food security, water conservation, and sustainable energy. CSIR is the nation's custodian for measurement standards of mass, distance, time, temperature, current, etc. CSIR is a pioneer of India's intellectual property movement, and is today strengthening its patent portfolio to carve out global niches for the country in select technology domains. CSIR has pursued cutting edge science and advanced knowledge frontiers. It has published around 5846 papers in SCI Journals in 2022 with an average impact factor of 4.9.

CSIR has also been focussing on human resource development and skill development in programmes like CSIR-JRF and Jigyasa to empower youth for better career and employment opportunities. CSIR, through its various constituent laboratories, is also placing major focus on creating incubation facilities for spin-offs and start-ups.

CSIR addresses national needs through its innovative research, strong fundamental science, industry partnerships, entrepreneurship, translation research, science communication, and policy making. Through its technological interventions, CSIR has provided solutions and innovations for the industry and has also proved to be a catalyst in improving the quality of life of millions of people across the country. As CSIR celebrates 84 years of its foundation, it continues to inspire scientific excellence, nurture innovation, and serve as a pillar of India's progress. Its legacy reflects a perfect blend of research and societal impact, making it a true symbol of 'Science for People, Science for Nation'.

Beginning of CSIR

CSIR was established on 26 September 1942. Before India's independence, in the 1930s, a need was felt to establish research organisations for the development of natural resources and new industries within the country. India's Nobel laureate scientists in physics C.V. Raman, Lieutenant Colonel Seymour Sewell and J.C. Ghosh proposed the creation of an advisory committee for scientific research. Sir Richard Gregory, editor of the world's prestigious research journal *Nature*, was one of the persons who officially reported to the British government. In 1933, Gregory, after visiting scientific departments and universities in India, submitted a report to Samuel Hoare, Secretary of State for the Republic of India, in which he put forward the idea of setting up a scientific department in India similar to the Department of Scientific and Industrial Research (DSIR) in Britain. During the same period, Indian scientists in Calcutta and Bangalore (now Kolkata and Bengaluru) made plans to start the National Institute of Sciences and the Indian Academy of Sciences respectively. On the occasion of the fifth industrial conference held in the country in 1933, the provincial governments of Bombay (now Mumbai), Madras (now Chennai), Bihar and Orissa (now Odisha) unanimously reiterated the demand for an organisation to coordinate industrial research. This was also advised to the then Viceroy by the Secretary of State for the Republic of India, Samuel Hoare, but he rejected the proposal and said that the establishment of DSIR in India was not useful. The British government instead formed the Industrial Intelligence and Research Bureau (IIRB) in 1935 with an annual budget of ₹1 lakh. It was difficult to carry out large-scale research and industrial activities within the country with such a meagre budget. The IIRB was abolished during the Second World War (1939).


Arcot Ramaswamy Mudaliar who played an important role in the establishment of CSIR

After this, Arcot Ramaswamy Mudaliar, a member of the Viceroy's Executive Council, recommended the British authority to form the Board of Scientific and Industrial Research (BSIR). After this, BSIR was formed on 1 April 1940 for a short period of two years. Mudaliar was made its chairman and Shanti Swarup Bhatnagar was the Director of this Board. BSIR was allocated an annual budget of ₹5 lakh by the Department of Commerce. By the end of 1940, BSIR had 80 researchers. In two years, this board developed technologies mostly in accordance with security and military requirements. The main technologies developed in these were anti-gas cloth, vegetable oil as fuel and lubricant, plastic cases for army boots and ammunition, dyes for uniforms and pyrethrum emulsifier. All these technologies were adopted by the industries. Thus, scientific and industrial research got a boost at that point of time.

In early 1941, Bhatnagar urged the British government to form the Industrial Research Utilization Committee (IRUC) with the objective of converting scientific research into practical use. The British government agreed to create a separate fund from the royalty received from the industry and reinvest the amount accumulated in that fund in industrial research. Mudaliar recommended the creation of an Industrial Research Fund for a period of five years with an annual grant of ₹10 lakh. His important recommendation was accepted by the Central Assembly, Delhi on 14 November 1941. This was a significant milestone for the formation of CSIR. On 26 September 1942, after the continuous efforts of Mudaliar and Bhatnagar, the Council of Scientific and Industrial Research (CSIR) was established as an autonomous body. It became functional from then onwards. BSIR and IRUC were absorbed as advisory units in the governing body of CSIR. In 1943, the governing body of CSIR approved Bhatnagar's proposal to establish five national laboratories. These five laboratories are National Chemical Laboratory (NCL), National Physical Laboratory (NPL), Fuel Research Station, Glass and Ceramic Research Institute and National Metallurgical Laboratory (NML). The following year in 1944, CSIR was given a grant of ₹1 crore for setting up these laboratories in the country in addition to the fixed annual budget of ₹10 lakh. Industrial houses of the country also came forward to help CSIR. Tata Industrial House donated ₹20 lakh for Chemical, Metallurgical and Fuel Research Laboratories. The foundation stone of the Central Glass and Ceramic Research Institute (CGCRI) in Kolkata was first laid in December 1945. After that, the foundation of National Metallurgical Laboratory (NML) in Jamshedpur was laid in November 1946 and the foundation of National Chemical Laboratory (NCL) in Pune was laid on 6 April 1947. India became independent from British rule just four months after the foundation stone of NCL was laid and all these five laboratories of CSIR were completed by 1950. After the independence of the country, Shanti Swarup Bhatnagar was made the first Director of CSIR. At that time, the highest officer of CSIR was called Director, which was later changed to Director General.

Shanti Swarup Bhatnagar, a visionary scientist of India and the first Director of CSIR

Shanti Swarup Bhatnagar was a visionary scientist and scientific organisation administrator of India. His area of expertise was colloid chemistry. He believed that fundamental research and purposeful applied research in the field of science are two sides of the same coin and one without the other has no importance. This basic concept became the background for the formation of CSIR. The objective of CSIR is to promote scientific knowledge as well as to promote industrial and economic development in the country.

The structure of CSIR organisation

It is a matter of pride for CSIR that the President of this scientific organisation is the Prime Minister of India. Its Vice President is the Union Minister of Science and Technology of the country. The Director General (DG) of CSIR serves as the ex-officio Chairman of the Governing Body (GB) of CSIR and its Chief Executive Officer. CSIR also has an Advisory Board consisting of 15 members. The tenure of these members is three years. These members are experts in various fields of science and technology. The function of this board is to advise the governing body of CSIR on matters of science and technology.

Science, technology and social concerns of CSIR

The common people and the national development created by them are at the core of CSIR's mission. In view of the national dreams and expectations of the century, the country's expectations from CSIR and other public-funded institutions have constantly increased. Scientific and technological development is directly related to national progress and economy. Human resources play an important role in the development of the country. The transformation of national needs into international opportunities is a new aspect of scientific progress in the present times. In accordance with the current socio-economic scenario, CSIR has set the following objectives:

- Leadership in the fields of science and engineering
- Innovative technological solutions
- Open innovation and top-notch resourcing

- Nurturing talent in diverse areas of science and technology
- Science-based entrepreneurship
- Socio-economic transformation through science and technology interventions.

CSIR covers a wide spectrum of science and technology ranging from oceanography, geophysics, chemistry, medicines, genomics, biotechnology and nanotechnology to mining, aeronautics, instrumentation, environmental engineering and information technology. This scientific organisation provides important technological interventions in many areas related to societal efforts including environment, health, drinking water, food, housing, energy, agriculture and non-agriculture sectors. Apart from this, CSIR's role in S&T-based human resource development is noteworthy.

CSIR's R&D themes to function

Recently, CSIR has undertaken several initiatives to translate laboratory leads to marketable/value-added technologies/products and thereby enhance interactions and connect to stakeholders for enabling ease of doing technology licensing. One of the initiatives is a 'thematic approach' to harness multidisciplinary talent and infrastructure for solving specific challenges in identified sectors. Theme directorates have been formed to cover the following specific sectors:

- Aerospace, electronics, instrumentation and strategic sectors
- Civil infrastructure and engineering
- Ecology, environment, earth and ocean sciences and water
- Mining, minerals, metals and materials
- Chemicals (including leather) and petrochemicals
- Energy (conventional and non-conventional) and energy devices
- Agri, nutrition and biotech
- healthcare

The theme directorates are envisaged to provide for greater alignment to and for enhancing industrial/stakeholder focus of CSIR R&D activities. The roadmap and activities of each theme would focus on substantial contributions towards each of the parameters– public good, private good, strategic good and societal good.

CSIR is a scientific organisation working with dedication in the service of the nation for the last 84 years. CSIR laboratories do cutting- edge research work in almost every field of life. This organisation has the support of excellent and experienced scientists and skilled technical staff. Whenever the country is surrounded by any crisis or problem, CSIR has resolved that problem through scientific research and technology development. The recent COVID-19 pandemic is a strong example of this. Many CSIR laboratories have made unprecedented contributions in important areas ranging from genome sequencing and repurposing of medicines to vaccine production. The scientists here worked day and night to fight this crisis on humanity with their weapon of research.

CSIR has pioneered innovations in almost every sector of national development– ranging from aerospace to agriculture, pharmaceuticals to energy, and materials to environmental sciences. Its legacy is not just in scientific publications or patents but in real-world solutions that have touched the lives of millions. CSIR has recorded innumerable scientific excellence since its inception till now. There will be a shortage of space to mention all those achievements here. Therefore, only a few selected achievements of CSIR are being mentioned here.

Contributions to healthcare and pharmaceuticals

One of CSIR's most significant achievements lies in the field of affordable healthcare. During the early decades, India was heavily dependent on imported drugs, making healthcare expensive. CSIR laboratories, such as the Central Drug Research Institute (CDRI) and Indian Institute of Chemical Technology (IICT), played a critical role in developing indigenous drug technologies.

- Essential medicines at low cost : CSIR scientists developed processes to manufacture life-saving drugs like anti- tuberculosis medicines, anti-malarial, and antibiotics, making them available to the masses at a fraction of the international cost.
- **Generic drug revolution:** CSIR's work paved the way for India's rise as a global hub for generic pharmaceuticals, ensuring drug availability at

affordable prices.

- **Biopharmaceuticals and vaccines:** CSIR laboratories contributed to recombinant DNA research, vaccine development, and diagnostic kits, including affordable COVID-19 testing solutions during the pandemic.
- **Ayush and traditional knowledge:** Through the Traditional Knowledge Digital Library (TKDL), CSIR documented thousands of formulations from Ayurveda, Unani, and Siddha texts, preventing their bio-piracy and protecting India's intellectual heritage.

Achievements in agriculture and food security

Agriculture has always been central to India's development, and CSIR's contributions have significantly enhanced food security.

- **High-yielding crop varieties:** CSIR labs namely Institute of Himalayan Bioresource Technology (IHBT) and National Botanical Research Institute (NBRI) have developed improved varieties of crops, including medicinal and aromatic plants, thereby enhancing farmers' income.
- **Agro-processing technologies:** CSIR laboratories pioneered food preservation, storage, and packaging technologies. These have reduced post-harvest losses and strengthened India's food processing industry.
- **Biofertilisers and biopesticides:** CSIR's eco-friendly solutions have reduced chemical dependence, promoting sustainable agriculture.
- **Floriculture and agro-business:** Through plant tissue culture and genetic improvement, CSIR has boosted the floriculture sector, enabling India to become a key player in the global cut-flower market.

Aerospace and engineering excellence

India's strides in aerospace and engineering owe much to CSIR's innovative contributions.

- CSIR-National Aerospace Laboratories (NAL) has developed several indigenous aircraft, including the HANSA trainer aircraft and SARAS light transport aircraft. These projects laid the foundation for India's aerospace engineering capabilities.
- **Wind tunnel testing facilities:** NAL provided critical aerodynamic testing for projects such as the Light Combat Aircraft (Tejas), rockets, missiles, and satellites, supporting ISRO and DRDO programmes.
- **Composite materials:** CSIR pioneered research in advanced composite materials, which have applications in aerospace, defence, and automotive industries.

Industrial development and manufacturing

CSIR's early mandate was to build industrial self-reliance, and it has lived up to this mission.

- **Process technologies:** CSIR developed thousands of process technologies in chemicals, petrochemicals, leather, paper, textiles, and fertilisers, which were transferred to industries across India.
- **Leather industry transformation:** Through CSIR-Central Leather Research Institute (CLRI), India became a global leader in leather exports. CLRI introduced eco-friendly tanning technologies, improving both quality and sustainability.
- **Steel and metallurgy:** CSIR-National Metallurgical Laboratory (NML) contributed to improving steel production processes and developing corrosion-resistant alloys.

Energy, environment, and climate science

With growing concerns about sustainable development, CSIR has been a leader in addressing environmental challenges.

- **Coal and energy research:** CSIR laboratories developed clean coal technologies, coal gasification methods, and processes for improving fuel efficiency.
- **Renewable energy solutions:** From solar energy to biofuels, CSIR has advanced renewable energy technologies.
- **Air and water purification:** CSIR developed affordable water filters such as the 'Solex' filter and air quality monitoring systems, directly benefitting rural and urban populations.
- **Climate and atmospheric research:** The CSIR-National

Institute of Oceanography (NIO) has made pioneering contributions to ocean science, while CSIR-National Physical Laboratory (NPL) has advanced climate monitoring and standardisation.

Infrastructure and rural development

CSIR's impact is also evident in grassroot innovations and rural development.

- **Low-cost housing materials:** CSIR-Structural Engineering Research Centre (SERC) developed affordable building technologies that provided safe and sustainable housing solutions in rural areas.
- **Water resource management:** CSIR introduced technologies for groundwater recharge, desalination, and rural water purification.
- **Skill development:** CSIR regularly trains thousands of rural entrepreneurs and small-scale industries, bridging the gap between research and livelihood.

Information and digital technologies

- **TKDL (Traditional Knowledge Digital Library):** A global model that protects India's heritage knowledge from bio-piracy.
- **IT applications:** CSIR contributed to data analytics, simulation technologies, and high-performance computing in collaboration with national programmes.
- **Open access knowledge repositories:** CSIR has made significant strides in knowledge dissemination through digital platforms.

Defence and strategic contributions

National security has been strengthened by CSIR's innovations.

- **Materials for defence:** CSIR developed lightweight composites, alloys, and polymers for defence applications.
- **Support to DRDO and ISRO:** Through testing, material science, and aerodynamics, CSIR enabled India's missile, rocket, and satellite programmes.
- **Protective gear:** CSIR

Landmark achievements of CSIR

- Manufactured India's first synthetic drug methaqualone in 1950.
- The indelible ink used in general elections was developed by CSIR-NPL in the 1950s. India exports this ink to more than 25 countries of the world.
- Developed optical glass for defence purposes at CSIR-CGCRI.
- Manufactured and commercialised Swaraj, India's first indigenously built tractor in 1967.
- CSIR developed a process for making buffalo milk-based infant formula with excellent digestibility.
- Bamboo plant flowers in nature over a period of 20 years. This was done by CSIR within a week.
- By analysing the genetic diversity of the Andamanese tribal human community for the first time, CSIR revealed that they originated in Africa 60,000 years ago.
- Developed first transgenic Drosophila model for drug screening related to cancer in humans.
- Invention of non-steroidal family planning pill named 'Saheli' and first non-steroidal herbal pill 'Asmon' for treatment of asthma.
- Designed India's first parallel processing computer 'Flosolver'.
- Revived a 100-year-old refinery in Digboi using technology for state-of-the-art molecular distillation.
- Developed 'Bio-Suit', an important portable PC-based software useful in bioinformatics in collaboration with TCS.
- Designed 14-seater plane 'Saras'.
- Developed the world's first 'Traditional Knowledge Digital Library' (TKDL), which can be accessed in five international languages (English, German, French, Japanese and Spanish) in addition to Indian languages.
- After a struggle, managed to get a patent from the US, for the use of turmeric for wound treatment.
- Sequencing of human genome was completed in the year 2009.
- Developed Drishti Transmissometer, which is a device to provide visibility-related information to the pilot for safe landing and take-off at the airport.
- On 27 August 2018, India's first flight was made from biofuel developed by CSIR's Indian Institute of Petroleum.
- Developed Solar Tree.
- Developed Lithium Ion Battery.
- Marine Expedition RV Sindhu Sadhana discovered new minerals and hydrocarbon resources in the ocean.
- Developed Divya Nayan for visually impaired people.
- Developed Intelligent Wheel Chair.
- Unique Virtual Lab Platform was set-up for students.
- For the first time planted asafoetida seeds for production of asafoetida in India.

Heeng cultivation by IHBT laboratory

contributed to development of bulletproof materials, combat uniforms, and NBC (nuclear, biological, chemical) protective systems.

International recognition and global collaboration

CSIR's work is not confined to national boundaries. It has collaborated with global organisations like WHO, WIPO, and international universities. Its patents and publications are widely cited, and its scientists have won numerous national and international awards.

COVID-19 response: A recent milestone

During the COVID-19 pandemic, CSIR's contributions stood out.

- Developed low-cost diagnostic kits
- Repurposed drugs for COVID-19 treatment
- Produced ventilators and protective equipment
- Supported industry in manufacturing sanitisers and essential drugs

Recent breakthroughs of CSIR

Heeng cultivation

The CSIR-Institute of Himalayan Bioresource Technology (IHBT), Palampur, has played a groundbreaking role in introducing heeng (asafoetida) cultivation in India. Traditionally imported from Iran and Afghanistan, heeng was never grown domestically due to unsuitable climatic conditions. CSIR-IHBT identified the cold desert regions of Lahaul-Spiti in Himachal Pradesh and Ladakh as ideal for its cultivation. Using innovative techniques like plant tissue culture, seed germination protocols, and farmer training programmes, IHBT successfully initiated the crop's adaptation. This achievement not only supports import substitution but also provides a high-value cash crop to farmers in challenging terrains, strengthening local livelihoods and India's spice self-reliance.

Indigenous, cost-effective Raman Spectrometer

The CSIR-Advanced Materials and Processes Research Institute (AMPRI), Bhopal, has developed an indigenous, cost-effective Raman Spectrometer, marking a significant achievement in India's scientific instrumentation. Raman Spectroscopy is a powerful analytical technique used to study molecular vibrations, material properties, and chemical compositions. By designing a compact and affordable version, CSIR-AMPRI has reduced dependence on expensive imports, making advanced research tools

Preserving original manuscript of Indian Constitution

The CSIR-National Physical Laboratory (NPL) plays a crucial role in preserving the original handwritten manuscript of the Indian Constitution. Since 1952, NPL has been the official custodian of India's national standards of measurement, including time and material preservation. Using advanced techniques in climate control, material science, and archival conservation, NPL ensures that the manuscript – written in ink on parchment – remains protected from deterioration due to light, humidity, and aging. This effort reflects CSIR's commitment beyond science and technology, safeguarding India's most sacred democratic document for future generations and upholding the nation's cultural and constitutional heritage with scientific precision.

accessible to Indian universities, research labs, and industries. This innovation supports diverse fields such as materials science, pharmaceuticals, nanotechnology, and forensic analysis. The indigenous spectrometer not only promotes self-reliance in high-end instrumentation but also aligns with the vision of *Atmanirbhar Bharat.*

Technology of nucleic acid staining dye GreenR™

The dye GreenR™ has been developed by CSIR-CDRI in collaboration with industry partner Biotech Desk Pvt. Ltd. (BDPL), Hyderabad. The product GreenR™ provides an economical alternative to commercially available dyes that are used to stain DNA/RNA, which are currently imported. It binds to all nucleic acids including genomic DNA, PCR products, plasmids and RNA and fluorescence under blue light or UV exposure. This dye has varied applications in molecular diagnostics and life sciences research.

Steel slag for road construction

India is the world's second largest steel producer. India generates around 19 million tons of solid steel slag waste annually. CSIR-Central Road Research Institute (CRRI) under a major research study sponsored by Ministry of Steel and four major steel industries in India, namely, JSW Steel, AMNS India, TATA Steel and Rashtriya Ispat Nigam Limited, has developed the steel slag valorisation technology to convert waste steel slag as road making aggregates. Processed steel slag aggregates as developed through waste steel slag has been successfully utilised in the construction of India's first steel slag road at Hazira, Surat. Around one lakh ton processed steel slag aggregates were utilised as 100 per cent substitute of natural aggregate in steel slag road construction. For its unique design features, the steel slag road built through CRRI technology has been inducted in India Book of Records and Asia Book of Records as the First Steel Slag Road.

Indelible ink

INDELIBLE IN
80 CC
Mysore Paints & Varnish Ltd.

Indelible ink, a symbol of India's democratic process, was first developed in 1950s by CSIR-National Physical Laboratory (NPL), New Delhi, in collaboration with the Election Commission of India and Mysore Paints and Varnish Ltd. The technology was exclusively transferred to Mysore Paints and Varnish Ltd. through National Research Development Corporation (NRDC), New Delhi. This violet-coloured ink, containing silver nitrate, is applied to voters' fingers to prevent double voting and electoral fraud. Over the decades, it has become an integral part of India's election identity, trusted for its reliability and permanence. Beyond India, indelible ink has been exported to more than 25 countries, strengthening democratic practices worldwide and showcasing India's scientific innovation in safeguarding free and fair elections.

Milestone of Indian Footwear Sizing System

CSIR-Central Leather Research Institute (CLRI) achieved a major milestone by developing the Indian Footwear Sizing System, the nation's first scientific and standardised footwear sizing framework. Earlier, India relied on foreign sizing systems, leading to discomfort and poor fitting for many consumers. CSIR-CLRI conducted an extensive anthropometric survey across the country, mapping foot dimensions of diverse populations to create a system tailored to Indian feet. This initiative ensures better comfort, health, and performance in footwear while also supporting the domestic footwear industry. The Indian Footwear Sizing System marks a step toward self-reliance, global competitiveness, and consumer-centric product development.

Uranium extraction from seawater

Uranium extraction from seawater is an emerging paradigm of the Blue economy towards harnessing the ocean resources for sustainable development of clean energy. The large area thin films of permanently porous Hydrogen-bonded Organic Frameworks (HOFs) have been prepared at CSIR-CSMCRI, Bhavnagar for efficient Uranium Extraction from Seawater (UES).

Floriculture Mission

CSIR Floriculture Mission Phase I was launched in March 2021 with the aim to utilise knowledge-base available in CSIR Institutes and help Indian farmers and industry. So far,

Steel Slag Road

1250 hectares have been brought under floriculture. Apiculture has been integrated with floriculture in collaboration with KVIC forming 49 clusters benefitting 2000 farmers and covering 4880 hectors. CSIR is implementing Phase II of Floriculture Mission with the aim to overcome the lack of indigenously produced quality planting materials (QPM).

Purple Revolution

The Purple Revolution, driven by the Council of Scientific and Industrial Research (CSIR) through its Institute of Integrative Medicine (IIIM), Jammu, focusses on the large-scale cultivation of lavender in India. Introduced under the Aroma Mission, it has transformed the livelihoods of farmers in Jammu & Kashmir by providing a high-value aromatic crop. CSIR-IIIM provides quality planting material, training, and distillation units for essential oil extraction, which has great demand in cosmetics, perfumery, and pharmaceuticals.

This initiative not only enhances farmers' income but also promotes rural entrepreneurship, employment generation, and India's entry into the global aromatic plants market.

OWOL and OWOT

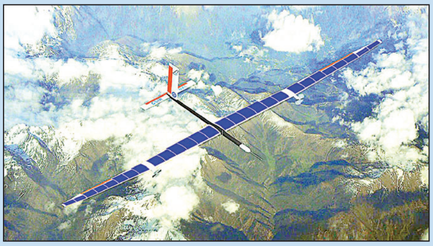
The One Week One Lab (OWOL) and One Week One Theme (OWOT) initiatives of CSIR aim to showcase scientific achievements and connect research with society. Under OWOL, each CSIR laboratory dedicated a week to highlight its innovations, technologies, and societal contributions through exhibitions, lectures, and outreach programs. Similarly, OWOT was focussed on a specific theme of national importance, promoting awareness, collaborations, and solutions in areas like health, energy, or environment. These initiatives strengthen industry-academia linkages, inspire young minds, and ensure that CSIR's research benefits reach the public, fostering scientific temperament, innovation, and inclusive growth for a self-reliant India.

Over the past 84 years, CSIR has transformed India's scientific landscape. From making essential medicines affordable to pioneering aerospace engineering, from empowering farmers to safeguarding the environment, its achievements have been both wide-ranging and deeply impactful. The hallmark of CSIR lies in its ability to align cutting-edge research with the needs of society and industry.

As India moves towards becoming a global innovation hub and achieving the vision of Viksit Bharat 2047, CSIR's role will remain indispensable. Its legacy of scientific excellence, coupled with social responsibility, stands as a testament to how science can truly serve the nation.

High Altitude Platform (HAP)

CSIR-NAL is developing High Altitude Platforms (HAP) for applications like broadband communication, surveillance, earth observation, climate research, etc. HAP is a solar powered unmanned aircraft envisaged to operate at the stratosphere regime, i.e. approximately 20 kilometre altitude, and with maximum endurance so that it can emulate a perpetual flight.



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Lab-Grown Foods: Sustainable and Humane Alternatives of Future

Dr. Punit Kumar

The global food industry is in the midst of a revolution driven by the urgent need to address the environmental, ethical and health challenges posed by traditional animal agriculture. As the world's population continues to grow, and concerns over climate change, animal welfare, and human health intensify, the demand for sustainable and ethical food alternatives is increasing. In response to these challenges, a new wave of food tech start-ups is emerging, focussed on developing innovative plant based and lab grown foods that have the potential to reshape the future of food. These start-ups are not only redefining how we produce and consume food but are also paving the way for a more sustainable and humane food system. India, with its burgeoning population and diverse dietary preferences, stands at the cusp of a significant transformation in the food industry. As global trends shift towards sustainability and ethical consumption, Indian start-ups are emerging as key players in the food tech space, particularly in the realms of plant-based and lab-grown foods. These innovations are poised to address pressing challenges related to food security, environmental sustainability, and health in a country that is rapidly urbanising and experiencing changing food consumption patterns. The rise of food tech start-ups in India highlights a dynamic shift towards creating sustainable and innovative food solutions that cater to both local and global markets.

(Source: https://ruralhandmade.com)

Plant-based food innovations

The plant-based food movement in India is rapidly gaining traction as more consumers become conscious of the environmental and health implications of traditional animal agriculture. A new wave of Indian start-ups is driving this change by developing innovative alternatives to conventional meat and dairy products. These companies are creating plant-based options that not only align with Indian culinary preferences but also

promote sustainability and health. From ready-to-cook kebabs and curries to plant-based burgers and sausages, these products are crafted to replicate the texture and flavour of meat while offering a more ethical and eco-friendly choice.

In the dairy segment, alternatives made from ingredients like oats and almonds are becoming increasingly popular. These products aim to address common health issues such as lactose intolerance while significantly reducing the carbon footprint associated with traditional dairy farming. Alongside these consumer-focussed developments, the industry is embracing cutting-edge food technologies like 3-D food printing and fermentation. These advancements are helping enhance the taste, texture, and nutritional value of plant-based offerings. Overall, the plant-based sector in India is witnessing dynamic growth, driven by innovation, shifting consumer preferences, and a shared vision of building a healthier, more sustainable food ecosystem.

Lab-grown alternatives

Lab-grown, or cultured meat, is emerging as a transformative innovation in India's food technology landscape. This method involves cultivating animal cells in controlled laboratory environments to produce real meat without the need for traditional livestock farming. The approach holds immense promise for addressing concerns related to animal welfare, environmental sustainability, and food security. By eliminating the need for animal slaughter, lab-grown meat reduces ethical concerns while also significantly lowering greenhouse gas emissions, land use, and water consumption associated with conventional meat production.

Indian innovators are actively exploring this field, focussing on the development of cultured meat products that align with local dietary habits and cultural sensitivities. These efforts aim to create sustainable alternatives that retain the flavour, texture, and nutritional profile of traditional meat, making them appealing to mainstream consumers. Emphasis is also being placed on scalability and affordability, with technologies such as bioreactors being used to cultivate meat cells efficiently and cost-effectively.

While still in its nascent stages, the lab-grown meat sector in India presents significant opportunities. It not only supports the transition toward a more sustainable food system but also has the potential to open up new markets and economic opportunities. As advancements continue, India

Tomorrow's Lunch

could play a key role in shaping the future of global food innovation.

Food-tech start-ups in India

India's vibrant food ecosystem, driven by growing consumer interest in health, sustainability, and innovation, presents a promising landscape for start-ups in plant-based and lab-grown foods. Aspiring entrepreneurs in this space can leverage a robust support network, state-of-the-art infrastructure, and a proactive policy framework to bring their ideas to life. The journey typically begins with in-depth market research to identify consumer needs and gaps, such as the rising demand for dairy alternatives, meat substitutes, or sustainable protein sources followed by product validation through pilot studies and tastings. Crafting a comprehensive business plan that addresses sourcing, technology, pricing, funding, and scalability is crucial, as is ensuring compliance with FSSAI regulations, especially for novel ingredients and labelling. Start-ups then move to prototype development and lab testing in collaboration with food scientists and R&D labs, particularly important in areas like cultured meat and fermentation-based proteins.

Funding opportunities are increasingly available through angel investors, venture capital, and government-backed schemes, while numerous incubators dedicated to food tech and sustainability, such as Atal Incubation Centres, Indigram Labs, IKP Eden, CCAMP, and T-Hub offer vital support in mentoring, prototyping, and market entry. India also hosts biotech and food processing clusters, including Biotech Parks in cities like Lucknow, Pune, and Hyderabad, and Mega Food Parks under the Ministry of Food Processing Industries, which provide shared infrastructure like testing labs, cold chains, and packaging units. Academic partnerships with institutions such as IITs, IISc, and agricultural universities further strengthen R&D capabilities in food engineering, biotechnology, and plant-based innovations.

The Indian government plays a crucial role in fostering food tech innovation. The Start-up India initiative offers tax incentives, IP assistance, and simplified compliance for registered start-ups, while the Production Linked Incentive (PLI) scheme for food processing supports performance-based incentives for new and export-oriented products. FSSAI is progressively framing guidelines for emerging food categories, including cultured meat and precision-fermented dairy, which help streamline the approval process. Support from the Department of Biotechnology (DBT) and BIRAC, through grants like the Biotechnology Ignition Grant (BIG), facilitates the transition from lab to market. For ventures focussed on plant-based wellness and nutraceuticals, the Ministry of AYUSH provides research grants and promotional assistance.

India's expanding middle class, increased awareness of climate change, and dietary transitions towards protein alternatives are creating a strong consumer base for smart protein products. According to the Good Food Institute India, this market is set to witness exponential growth over the next decade, opening avenues for innovations in vegan seafood, cultivated meat, fermented dairy, and hybrid food products. Start-ups that blend scientific innovation with traditional Indian culinary tastes stand to succeed not only in domestic markets but also in global exports. With its youthful talent pool, strategic geographic position, and cost advantages, India is fast emerging as a global hub for food tech innovation.

Challenges and opportunities

While India's plant-based and lab-grown food sectors are growing rapidly, start-ups in this space face notable challenges. High production costs remain a major barrier, making these alternatives more expensive than traditional meat and dairy products. To achieve mass-market appeal, reducing costs through innovation and scale is essential. Consumer acceptance is another hurdle, as India's rich culinary heritage and dietary habits may slow the adoption of novel food technologies. Building trust through awareness campaigns, culturally relevant products, and targeted marketing will be key. Additionally, navigating the regulatory landscape poses challenges. While FSSAI is working to frame guidelines for novel foods, the evolving nature of regulations demands clarity and compliance from start-ups. Despite these obstacles, the outlook remains optimistic. With rising demand for ethical, sustainable food and advancements in technology, Indian start-ups that tackle these issues head-on can lead transformative change and position India as a global leader in the future of food innovation.

The impact on food system

The emergence of plant-based and lab-grown foods holds the potential to significantly reshape India's food system across multiple dimensions. Environmentally, these alternatives offer a more sustainable option to conventional animal agriculture, consuming fewer natural resources and generating lower greenhouse gas emissions. Lab-grown meat, in particular, can drastically reduce the ecological footprint associated with livestock farming. From a health standpoint, these innovations may help reduce the risk of chronic diseases by offering cleaner, additive-free alternatives to traditional meat and dairy products, thereby supporting better public health outcomes. Economically, the expansion of this sector opens new avenues for job creation, entrepreneurship, and industrial growth. As start-ups scale and diversify, they attract investment and fuel innovation, positioning India as a prominent player in the global food tech space. Socially and culturally, rising interest in ethical and sustainable food choices could gradually shift dietary patterns and culinary habits, leading to greater acceptance of plant-based and lab-grown foods in Indian cuisine and everyday consumption.

Looking ahead

To support this growing ecosystem, the Indian government has introduced several promotion schemes. The Start-up India Initiative offers tax exemptions, funding access, and compliance support for tech-driven ventures, including food tech. The Start-up India Seed Fund Scheme (SISFS) provides early-stage financial assistance. Additionally, the National Mission on Food Processing supports R&D and infrastructure for food innovation. For manufacturing-scale support, MSME Innovation Schemes and Make in India initiatives offer financial incentives, mentorship, and market access. Further, schemes like PRITHVI (Promoting Research and Innovation Through Tech Hubs and Viable Incubation) are beginning to explore sustainable and climate-resilient food solutions.

With government backing and increasing consumer awareness, India is poised to become a global hub for sustainable food technologies. The synergy of innovation and policy is driving the future of food, where plant-based and lab-grown foods will play a central role in nourishing a growing population responsibly.

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Martial Rights and IPR

Dr. Sukanya Datta

Intellectual Property Rights (IPR) are legal rights granted, for a limited period, to persons over the creations of their minds. Martial arts on the other hand, are systems of self-defence, a term that immediately invokes a sense of physical involvement. Often, martial arts involve a choreographed pattern of correct stances and movements (Kata in Japanese). Martial arts may involve unarmed hand to hand combat or combat with specialised weapons. Examples include Morengy, a Malagasy kickboxing style that has a lineage spanning from the 17th century to the present day. From Tamil Nadu, India, comes Silambam (armed combat) with roots going back to the 4th century BC. Interestingly, Manipur is known for both the armed, and the unarmed, versions of martial arts. The former is named Thang Ta while the latter is named Sarit Sarak.

The connection between IPR and the Martial Arts is not always immediately obvious. This is because martial arts are deeply rooted in culture, and their intellectual property aspects can sometimes be difficult to interpret and/or enforce. Interestingly, however, IPR covers multiple elements common to the many schools of martial arts for example, Taekwondo, Judo, Karate, and Kalaripayattu and Kung Fu. Of course, these codified systems of combat date back centuries and so, are in the public domain (excluded from IPR protection). Be that as it may, Intellectual Property Rights such as Trademarks, Copyright,Patents, and Trade secrets still apply.

Source: https://www.vivytravel.com/discover-malagasy-moraingy/

Source: https://mapacademy.io/article/silambam/

Trademark

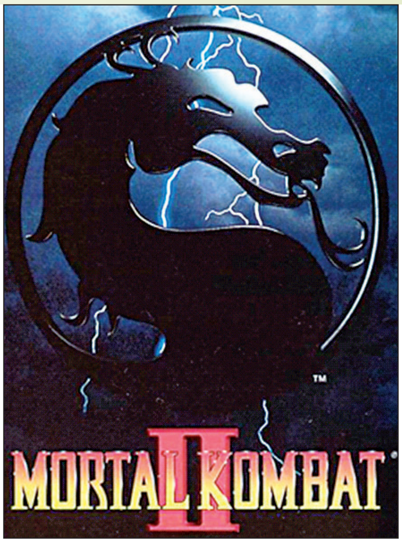
Since the roots of most schools of martial arts go back for centuries, the techniques themselves are often considered public domain. However, Trademarks can be used to protect the brand identity of a school, system, businessor even specific techniques. A Trademark is a sign/symbol unique to the product/services/company. It distinguishes one product from the other. IPR laws govern the use of Trademarks. Indian trademark law protects trademarks as per the Trademark Act, 1999.

(https://ipindia.gov.in/writereaddata/Portal/ev/TM-ACT-1999.html) Infringements attract penalty.

Trademarks help to establish identity or the 'Brand'. This helps prevent unauthorised people from falsely representing themselves as being associated with the particular organisation. According to Wikipedia, the name Tae Soo Do (Way of the Warrior Spirit) refers to a martial art programme created in 1990 by the World Hwa Rang Do Association as a beginner'sprogramme to the martial art system Hwa Rang Do. HWA RANG DO® and TAE SOO DO ® are registered tradenames held by the Founder Dr. Joo Bang Lee and are licensed and controlled by the one and only governing organisation, the World Hwa Rang Do® Association. (https://hwarangdo.com/more/trademark/) The symbol R inscribed inside a circle shows that it is a trademark that has been officially registered with a national trademark office. It indicates that the owner of the trademark has exclusive legal rights to use that mark for the specified goods or services.

Copyright

Copyright covers the legal rights that creators have over their creative works such as novels, poems, painting or even, computer programs. These rights are designed to protect the creator of the work against unauthorised use of the work. Therefore, instructional manuals, videos, and any written or visual material related to martial arts are subject to copyright protection. This means the creator has exclusive rights to copy, distribute, and adapt these materials. The holder of the Copyright can negotiate with those wishing to make use of the copyrighted material.



Source: https://en.wikipedia.org/wiki/Mortal_Kombat_II

There has been at least one Copyright case where martial arts and performance artists sued alleging infringement of their right of publicity and unauthorised use of their names and likenesses (although agreements were signed) connected to home video game versions of Mortal Kombat and Mortal Kombat II.(More details about the Ahn v. Midway Manufacturing Co. case: https://descrybe.ai/case-details/c2138964).

Patent

A patent is the exclusive right granted for an invention of a technical product or process provided it meets the following criteria:

- Novelty (There must be no public knowledge about it before the patent application is filed. Any pre-existing knowledge (prior art) may lead to the application being dismissed).
- Non-obviousness or inventiveness (The invention must not be obvious to someone skilled in the field).
- Industrial applicability (The invention must have practical applicability).

Natural phenomena, abstract ideas,etc. cannot be patented.

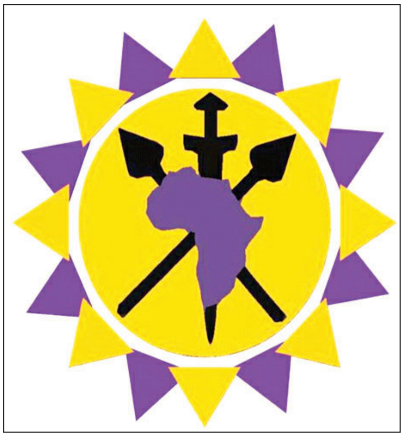
In the field of martial arts, certain techniques or equipment are eligible for patent protection. Specially

Source: https://www.backkicks.com/jhoon-rhee-safety-equipment/

designed tools and equipment can be patented in addition to being trademarked,etc. There are multiple martial arts-related patents granted to Jhoon G. Ree often referred to as Father of American Taekwondo. One such is a protective Karate glove, which was patented in 1980. Jhoon Ree invented safety equipment specifically designed for martial arts. No one in martial arts had worn safety gear before he invented it, so he is pretty much a pioneer in the field.

Trade Secrets

The term Trade Secret refers to specialised information that is not readily available to everyone. It is thus a secret. Additionally, it has relevance to an enterprise/business hence, the prefix, trade. The term covers confidential information that provides competitive advantage in any business. To be considered a Trade Secret, the information must:



Source: https:// hamaassociation.wordpress.com/

- only be known to a limited number of people outside the business
- only be accessed by a chosen few employees of the business
- have commercial value as a secret to both the holder/owner and the competitors
- be substantially difficult to acquire by outsiders; especially because efforts have been made to keep it a secret In case of martial arts, trade secret may well include a unique style of combat, or a distinctivetraining method, or a combination of choreographed stances. This information is kept confidential and is not publicly known. Those who join the programme may be asked to sign non-disclosure agreements. In contrast to patents, trade secrets rely on secrecy to maintain their value.

- Martial arts expert Bruce Lee died in 1973. Yet, his Intellectual Property Rights battles, especially those related to the unauthorised use of his image/name, pop up quite regularly. One such situation arose, about a decade back, whenthe lawyers representing Bruce Lee's estate sued movie producers proposing to use a digitally created version of his image for a movie. The issue arose over claims and counterclaims of who actually owned the IP-Rights.
- In 2019, a popular Chinese fast-food chain was suedbecause the restaurant's logo showed an image of Bruce Lee; without legal authorisation.Recently, the Beijing Intellectual Property Court and the Beijing Higher People's Court have upheld a final judgment confirming the invalidation of the graphic trademarks registered by restaurant. The court ruled that these marks constitute 'deceptive signs' under Chinese law. This decision was selected as one of the Top 10 Trademark Authorization and Validation Cases in Beijing Courts in 2024. (https://www.asialaw.com/NewsAndAnalysis/china-allbright-successfully-defends-bruce-lees-trademark-rights-zhen-gongfu/Index/2310#:~:text=The%20Beijing%20Intellectual%20Property%20Court,Version%20Trademarks%20(e.g.%2C%20No.)

Trends

Interestingly, the website of the World Intellectual Property Organization (WIPO) shares information about the Historical African Martial Arts Association (HAMAA)which "…is dedicated to the research, preservation, restoration, and propagation of the martial disciplines of Africa and its global diaspora community." (https://www.wipo.int/en/web/ip-advantage/w/stories/hamaa-historical-martial-arts-protection)

Under its aegis are different schools of martial arts including the Egyptian Tahtib with origins dating back to the Bronze Age; South African martial art Nguni Stick-Fighting, Shaka Zulu; and 52 blocks, which areAfrican Americanmartial art. Perhaps HAMAA's Chief Operating Officer, Adam Myrie hit the nail on the head when he said, "…for us, the culture and martial arts can't be separated..." (https:// www.wipo.int/en/ web/ip-advantage /w/stories/ hamaa-historical-martial-arts-protection)

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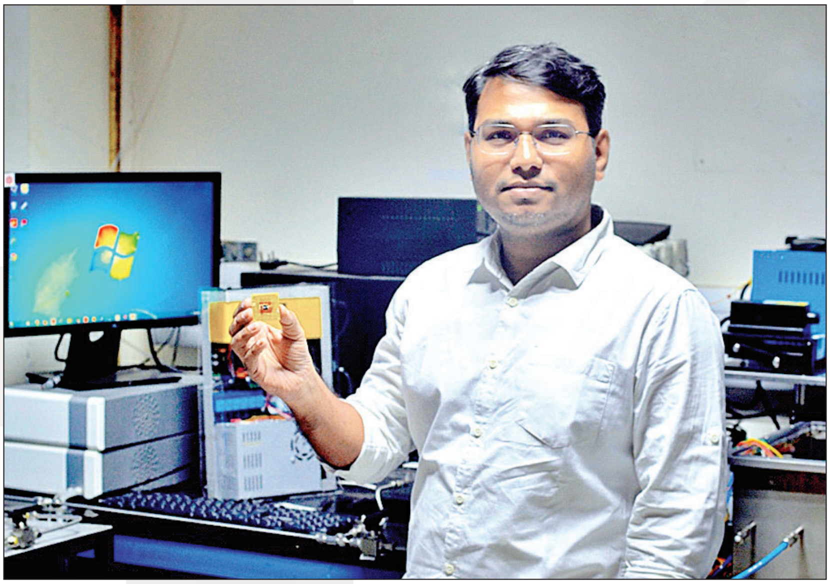
Smart sensor for efficient detection of hazardous gases



Dr. Vinayak Kamble with a miniaturised sensor device chip made in the laboratory

A low-power, miniaturised technology could now detect leakage of traces of explosive hydrogen during its use as clean fuel as well as very small amounts of toxic nitrogen dioxide that may be emitted from burning of fossil fuels in gas stoves and kerosene heaters.

Hydrogen is emerging as a clean energy source with applications in fuel cells, transportation, and industry. However, it is also highly flammable and explosive even at low concentrations. Detecting hydrogen gas leaks reliably – especially at room temperature – is critical for ensuring safety in storage, transportation, and usage. Traditional gas sensors often require high operating temperatures and consume significant energy, making them unsuitable for portable or on-chip applications. Therefore, there exists an urgent need for miniature, low-power, room-temperature hydrogen sensors that are sensitive, selective, and scalable.

Researchers at the School of Physics, IISER Thiruvananthapuram have been on the lookout for a sensor that could detect hydrogen at room temperature, even in trace quantities. The project was supported by the Nano Mission Programme of the Department of Science and Technology (DST).

Their breakthrough came from interfaces formed on to one dimensional nickel oxide (NiO) nanostructures like suspended nano-beams and nanowires functionalised with materials like nickel metal nanoparticles and/or Zinc oxide (ZnO) nanoparticles. Conventionally, NiO is a p-type semiconductor whereas ZnO is n-type.

When these materials are layered together into core-shell like nanostructures, the boundary – the so-called pn junction (between NiO-ZnO) at the nanoscale – becomes exquisitely sensitive to changes in the environment.

A whiff of hydrogen made the electrical conduction through the material change dramatically. The team consisting of Dr. Vinayak B Kamble, Associate Professor, IISER Thiruvananthapuram, Dr. Kusuma Urs, MB, Ph.D student IISER Thiruvananthapuram, Prof. Navakanta Bhat, CeNSE, IISc Bangalore and Mr. Krutikesh Sahu, CeNSE, IISc Bangalore pushed the idea further. They sculpted suspended nanobeams of nickel and nickel oxide with surgical precision using semiconductor fabrication tools. They also explored a more affordable route -growing ZnO/NiO junctions with simple solution methods. In both cases, it resulted in highly selective hydrogen detection at room temperature, with performance that left conventional sensors in the dust.

The series of studies published in *Sensors and Actuators B* and *ACS Applied Electronic Materials,* addresses the need for fast, reliable, and energy-efficient gas sensors for strategic sectors such as clean energy, aerospace, and environmental monitoring. With the upcoming Internet of Things (IoT) technologies, sensors are not only used for safety and preventive measures but also used to have energy savvy environment for precise control of atmosphere.

Most commonly used hydrogen sensors currently are made of an expensive metal called Palladium (Pd) that has high affinity for hydrogen. However, it suffers from the problems like poor sensors signal recovery and use of Pd increases the cost of production. While Nickel belongs to the same chemical group in periodic table, thus has very similar chemical properties but the price is 1/10th of Pd.

The developed sensors can help real-time hydrogen leak detection in fuel stations, vehicles, and industrial plants and thus can prevent accidents and save lives, monitor volatile organic compounds (VOCs) in polluted urban environments, enable safer deployment of hydrogen as a clean energy source, aiding India's green transition goals; and being lightweight they can be used in defence and aerospace. With scalable fabrication already demonstrated, the research opens the door for a new generation of compact, efficient, and smart gas sensors that could become standard components in various safety and monitoring systems across industries. Subsequent to this, the group has followed up the work using an oxide semiconductor array made up of NiO, CuO and ZnO based sensors to generate a dataset for AI-assisted sensors development last year; and currently it is advanced to ultra-low power and self-powered gas sensor devices made of atomically thin materials based heterostructure fabricated by CMOS compatible methods that are selective to either hydrogen in one case and toxic Nitrogen dioxide (NO_2) in the other case, just by tailoring the deposition conditions.

Golden key to detection of Parkinson's Disease

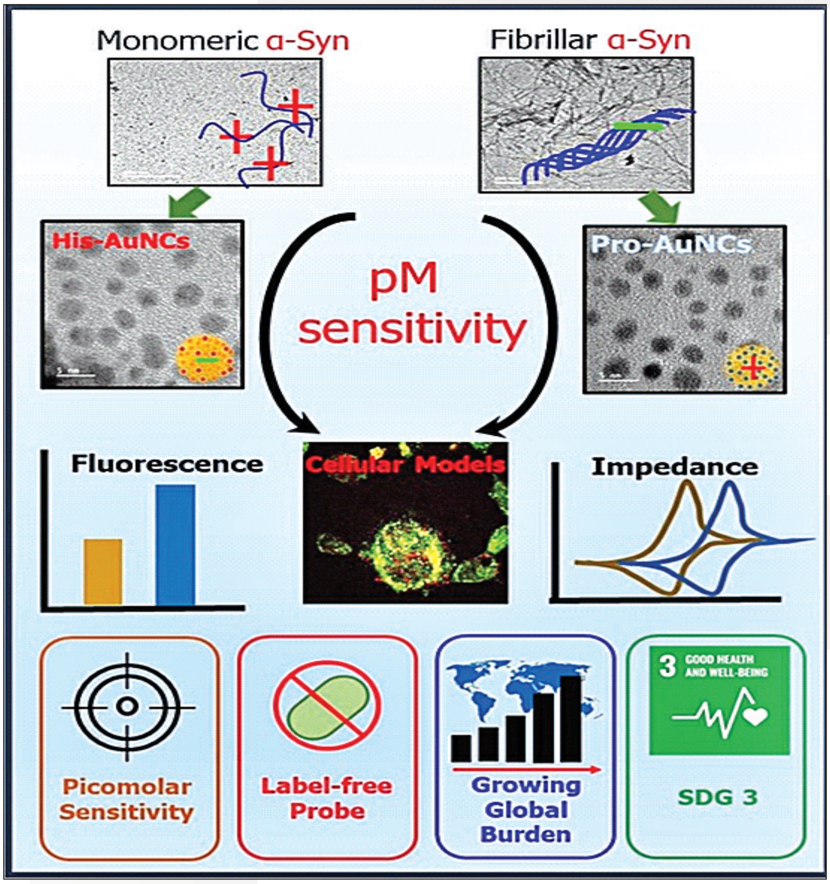
The yellow metal, rather tiny particles of it, can hold the key to a nanotechnology-based tool for early detection of Parkinson's Disease (PD).

Parkinson's disease is one of the fastest-growing neurological disorders globally. With an aging population and rising life expectancy, the number affected by the disease in India is projected to increase substantially, placing immense pressure on healthcare systems. Yet, most diagnoses occur only after significant neurodegeneration has already taken place.

Hence, researchers are on the lookout for ways in which the disease can be detected at an early stage so that adequate measures can be taken to manage it appropriately.

A group discussion among scientists at Institute of Nano Science and Technology (INST), Mohali an autonomous institute of the Department of Science and Technology (DST) exploring how proteins behave differently in the brain during disease, sparked a big idea. They started exploring whether they could detect how dangerous a protein is just by sensing its surface charge.

They focussed their attention on a protein called αsynuclein linked to PD. This protein changes shape, starting out harmless, and eventually clumping into toxic forms that damage brain cells. The team started working towards a sensor to tell these protein



Gold nanocluster-based biosensor distinguishes between physiological and pathological αsynuclein conformers, enabling early-stage detection of Parkinson's disease

forms apart, just by how they're charged.

Their solution came in the form of gold nanoclusters (AuNCs), ultrasmall, glowing particles just a few nanometers wide. By coating these nanoclusters with naturally occurring amino acids, the researchers gave them selective 'stickiness'. Proline-coated clusters were drawn to the normal version of the protein, while histidine-coated ones latched onto the toxic aggregates. This helped distinguish between the harmless monomeric form and the toxic aggregated (amyloid) form.

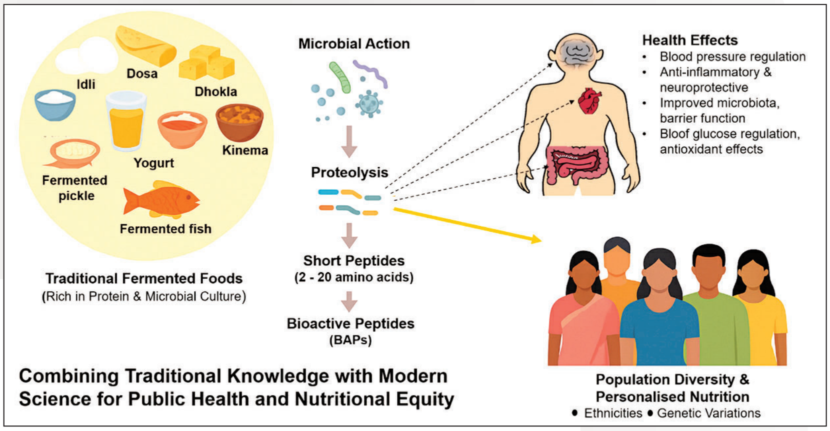
The journey from concept to proof-of-principle involved a broad spectrum of experiments. The team began by engineering and purifying two forms of the αsynuclein protein (normal and mutant). They then synthesised the amino acid-capped gold nanoclusters and meticulously characterised them using high-end techniques such as UV-Vis spectroscopy, fluorescence imaging, electron microscopy (TEM), and X-ray photoelectron spectroscopy (XPS) to understand their optical and structural properties. The interactions between nanoclusters and proteins were studied through gel electrophoresis, fluorescence quenching, and electrochemical methods like cyclic voltammetry and impedance spectroscopy, which allowed the team to measure how sensitively the nanoclusters could detect different forms of the protein. Finally, the system was tested in human-derived SH-SY5Y neuro-blastoma cells to ensure it worked safely and effectively in biological conditions. The project was led by Dr. Sharmistha Sinha, Senior Scientist at INST, and was supported by her Ph.D. students Ms. Harpreet Kaur and Ms. Ishani Sharma. They also collaborated with Dr. Deepak Sharma and Arpit Tyagi at CSIR-Institute of Microbial Technology (IMTECH), Chandigarh, who contributed their expertise in protein biochemistry and cell-based assays. This collaboration between young researchers and experienced scientists helped turn a simple lab discussion into a validated bio-sensing platform.

A tool that can detect the disease before symptoms appear could mean earlier treatment, improved quality of life, and lower long-term healthcare costs. The research also opens the door to detecting other diseases linked to misfolded proteins, like Alzheimer's, using similar nanotechnology. By making the system label-free, low-cost, and clinically adaptable, the team hopes it can someday be used in point-of-care testing – bringing powerful diagnostics closer to people who need them most. It could contribute to the global effort to prevent and manage non-communicable neurological diseases. The study has just been accepted at the journal *Nanoscale* (Royal Society of Chemistry).

Traditional fermented foods can provide personalised nutrition

A study of population-specific responses to fermented food shows that the health effect of the bioactive peptides they contain, differ across populations and can personalise nutrition for India's diverse population. Bioactive peptides from fermented foods are gaining global attention for their health benefits. With advancements in biotechnology and a deeper understanding of individual differences, bioactive peptides could hold great promise for nutrition and health solutions.

A recent study conducted by Institute of Advanced Study in Science and Technology (IASST), Guwahati, an autonomous institute of the Department of Science and Technology (DST) emphasises the health benefits of traditional fermented


Dosa
Idli
Dhokla
Kinema
Yogurt
Fermented pickle
Fermented fish
Traditional Fermented Foods
(Rich in Protein & Microbial Culture)
Microbial Action
Proteolysis
Short Peptides
(2 - 20 amino acids)
Bioactive Peptides
(BAPs)
Health Effects
• Blood pressure regulation
• Anti-inflammatory & neuroprotective
• Improved microbiota, barrier function
• Bloof glucose regulation, antioxidant effects
Population Diversity & Personalised Nutrition
• Ethnicities • Genetic Variations
Combining Traditional Knowledge with Modern Science for Public Health and Nutritional Equity

foods. They showed that the bioactive peptides (BAPs) or short protein fragments consisting of 2 to 20 amino acids that they contain can regulate blood pressure, blood sugar, immunity and inflammation. The study published in Food *Chemistry* (2025), led by Prof. Ashis K. Mukherjee, Corresponding author and Director IASST, Dr. Maloyjo Joyraj Bhattacharjee, Dr. Asis Bala, and Dr. Mojibr Khan showed that foods such as yogurt, idli, miso, natto, kimchi and fermented fish contain high levels of these peptides.

These short peptides, formed during fermentation, interact with biomolecules through electrostatic forces, hydrogen bondingand hydrophobic interactions to exert antimicrobial, antihypertensive, antioxidant and immune-modulatory effects.

This can influence cardiac function, immune response and metabolic health. However, their bioavailability and effectiveness vary across populations due to genetic polymorphisms, gut microbiota composition, dietary habits and health conditions. Gene variants in ACE or IL-6 may affect individual responses to these peptides. This data emphasises the necessity for precision nutrition and targeted health interventions customised to the diverse Indian population.

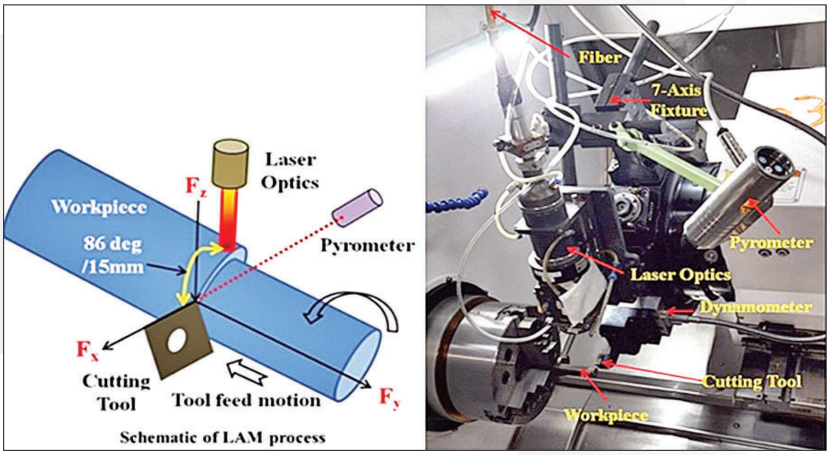
The research published in the journal *Food Chemistry* can address challenges such as variability in fermentation methods, peptide stability and interactions with the microbiota. The study advocates incorporating traditional fermented foods into public health initiatives. It emphasises the need for omics-based (biological research that utilise high-throughput technologies to analyse large sets of molecules) research and innovation in rural food systems to establish India as a global leader in personalised nutrition.

New technology promises efficient machining of super-alloys

A new technology promises to transform how we cut through some of the hardest materials known to engineering like Inconel 625 (IN625), which are used in areas ranging from aerospace and chemical to nuclear as well as in power production systems, such as boilers, heat exchanger tubes, and steam turbines.

The hybrid technique called Laser-Assisted Turning (LAT), that combines localised laser heating with mechanical cutting of such super-alloys using tools coated with materials like tungsten carbide and CrAlSiN nano-composite as well as the wear mechanisms of tungsten carbide cutting tools during the machining of IN625 super-alloy, paves way for next-generation turbine blades, surgical tools, and high-performance automotive parts that are lighter, stronger, and more efficient. Machining super-alloys, the ultra-tough metals used in jet engines, nuclear reactors, and space vehicles, has always posed a challenge. Their exceptional strength and heat resistance – qualities that make them indispensable – also make them incredibly difficult to shape. Traditional cutting tools struggle, suffering rapid wear and producing inconsistent results. But now, ARCI researchers have cracked the code.

Under the Clean Coal Research Initiative of the Department of Science and Technology (DST), researchers at the International Advanced Research Centre for Powder Metallurgy and New Materials (ARCI) have successfully demonstrated the effectiveness of Laser-Assisted Turning (LAT) for machining high-performance materials such as



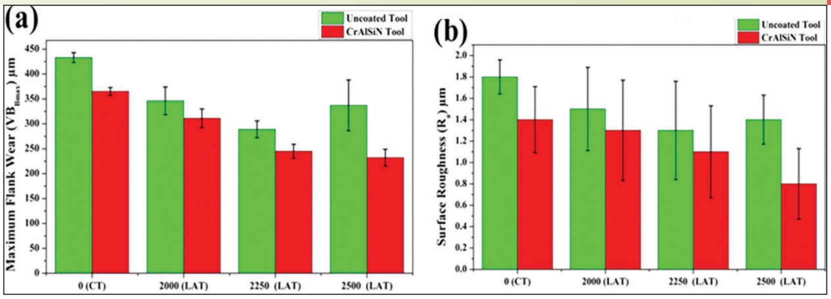
(a) schematic of LAM, and (b) LAM system at ARCI

Inconel 625 (IN625), a nickel-based super-alloy. This breakthrough offers a scalable, high-precision solution for industries that require the machining of difficult-to-machine materials, particularly in aerospace, power generation, and marine sectors.

IN625 is renowned for its exceptional mechanical strength, corrosion resistance, and ability to endure extreme temperatures. While ideal for demanding environments, its inherent toughness poses serious machining challenges, such as excessive tool wear, high cutting forces, and poor surface finish, when using traditional turning techniques.

To overcome these limitations, researchers of ARCI, an autonomous institution of the Department of Science and Technology (DST) developed Laser-Assisted Turning, a hybrid technique that combines localised laser heating with mechanical cutting. A high-power diode laser (up to 2500W) precisely heats the workpiece just ahead of the cutting tool, inducing thermal softening in the material. This significantly reduces cutting resistance, improves chip formation, and enhances tool life and machining quality.

The study evaluated the turning of IN625 using both uncoated tungsten carbide tools and CrAlSiN nanocomposite-coated tools, known for their superior hardness, thermal stability, and oxidation resistance. When paired with LAT, these coated tools delivered outstanding performance such as, 69 per cent reduction in cutting force, 46 per cent lower tool wear, and 56 per cent improvement in surface finish compared to conventional methods. The team has also investigated the wear mechanisms of tungsten carbide cutting tools during the machining of IN625 super-alloy at elevated temperatures. A key innovation was the integration of a Computer Numerical Control (CNC) turn-mill centre with a fibre-coupled diode laser, custom-designed adapters, and real-time monitoring tools.



(a) Tool wear (VBBmax) and (b) Surface roughness (Ra) in conventional and laser-assisted machining of IN625 alloy with uncoated and CrAlSiN nanocomposite-coated WC tools

The novelty of the approach lies in the synergistic use of LAT with advanced tool coatings, a combination not widely explored earlier. These results underscore the effectiveness of thermal softening when paired with surface-engineered tools. The CrAlSiN-coated tools, in particular, demonstrated excellent resistance to wear mechanisms like abrasion and oxidation while maintaining cutting-edge sharpness and dimensional accuracy under high temperatures. Their study wear mechanism of tungsten carbide cutting tools during the machining of IN625 super-alloy, revealed that it transitioned from fatigue and abrasion at room temperature to oxidation and adhesion-dominated behaviour at higher temperatures. These insights could help in understanding tool failure modes and estimating the thermal stability and service life of the cutting tool.

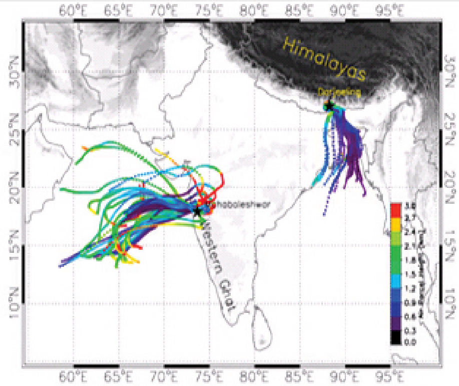
This technological advancement published in the journal *Process Mechanical Engineeringand Materials Letters* offers a significant leap in the machinability of super-alloys, opening new avenues for high-strength, high-precision components. It also aligns with India's strategic goals of boosting domestic manufacturing, improving energy efficiency, and adopting cleaner industrial technologies.

Toxic metals found in Himalayan clouds

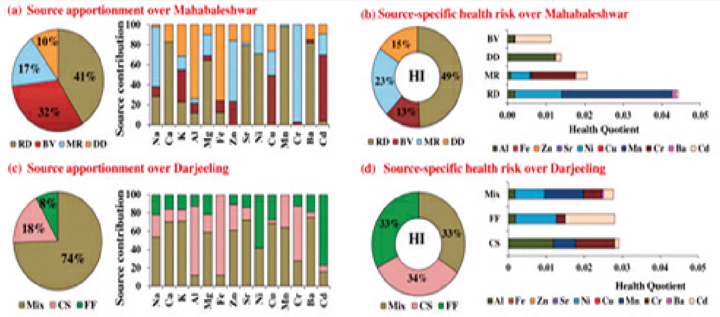
In the lofty heights of the Himalayas, where clouds drift over snow-capped peaks, a dangerous secret is being carried on the wind. A new scientific study has found that clouds – once believed to offer the purest drinking water – are silently ferrying toxic heavy metals from polluted lowlands to some of Earth's highest, most fragile ecosystems.

The findings not only shatter the myth of 'clean' mountain rain but also ring alarm bells for human health, with potential risks ranging from cancer to developmental disorders.

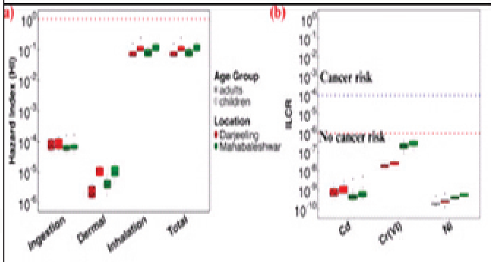
'Metals in the cloud' is a matter of growing concern due to its adverse



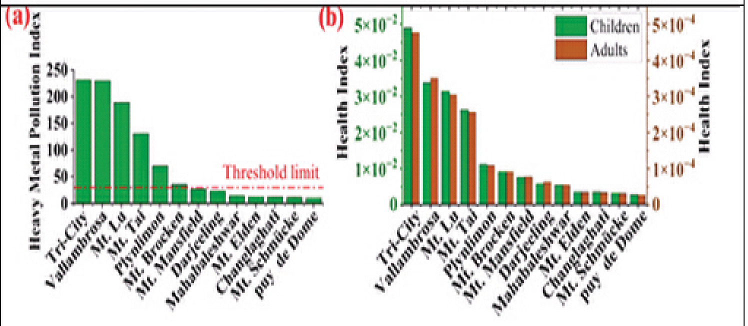
Possible trajectories of cloud movements in India



(a-b) source apportionment (%) and individual cloud-borne metal specific source contribution (%); and (c-d) source-specific health risk parameters like total HI and total HQ with individual cloud-borne toxic metal contribution over Mahabaleshwar and Darjeeling



(a) Non-carcinogenic health risk (HI) through different exposure routes for children and adults, and (b) carcinogenic health risk (ILCR) through inhalation of carcinogenic metals over Mahabaleshwar and Darjeeling in India



(a) Heavy metal pollution index (HPI), and (b) non-carcinogenic risk from the cloud water over different locations in the world

impact on human health on a wider scale through continental long-range transport. However, information regarding metal contamination of low-level clouds, particularly the late summer and early monsoon clouds in India is lacking,

Bose Institute, an autonomous institute of the Department of Science and Technology (DST) spotted toxic metals in non-precipitating clouds during the onset of monsoon over the Western Ghats and Eastern Himalayas. They also found that clouds over the Eastern Himalayas had 1.5 times higher pollution levels due to an increase in 40-60 per cent higher loading of toxic metals like Cd, Cu, and Zn emitted from heavy traffic and industrial emissions that cause high health risk factors from carcinogenic diseases. The Atmospheric research team, led by Dr. Sanat Kumar Das, Associate Professor, Bose Institute quantified the risk of carcinogenic and non-carcinogenic diseases through inhalation, ingestion, and dermal absorption. They conducted a detailed study using statistical models to identify the possible sources of these metals. The results from the current observation and simulations showed that children are at 30 per cent higher risk from such toxic metals than adults in India. Inhalation of polluted clouds over Eastern Himalayas containing high concentrations of toxic metals is the most potential route for non-carcinogenic diseases.

Besides, the study showed that health risk for the occurrence of carcinogenic diseases has increased due to inhalation of dissolved Cr present in clouds. The study highlights that Eastern Himalayas experience higher polluted clouds containing toxic metals like Cd, Cr, Cu, and Zn coming from vehicular and industrial emissions over foothill regions. Inhalation of such polluted clouds is the potential cause of carcinogenic and non-carcinogenic diseases in India.

Clouds acting as transport medium carry dissolved heavy metals, posing serious health risks to people, due to carcinogenic and non-carcinogenic diseases, through skin contact, inhalation, and consumption of precipitation-collected water in high-altitude regions. The study published in *Environmental Advances* opens up a new direction for research on atmospheric pollution and public health. However, the analysis shows that Indian clouds till now remain relatively less polluted, placing India in a safer health zone compared to countries like China, Pakistan, Italy, and the USA. **(DST MEDIA Cell)**

NRDC Offers Peptide-Based Disease-Modifying Therapy for Parkinson's Disease

Priyanka Aswal

PARKINSON DISEASE

Parkinson's disease (PD) is the second-most common neurodegenerative disorder after Alzheimer's, affecting around 8-10 million people worldwide. Its incidence rises steeply with age, and men are about 1.5 times more at risk than women. In India, roughly 0.58 million people were estimated to have PD as of 2016-2017. PD is a major cause of disability in adults - globally in 2019 it accounted for ~5.8 million disability-adjusted life years and ~329,000 deaths - imposing a heavy burden on patients, families and healthcare systems. Common symptoms include tremor, bradykinesia, rigidity and postural instability, often accompanied by non-motor issues (dementia, sleep and autonomic dysfunction). There is currently no cure or disease-modifying treatment for PD. Existing therapies only ease symptoms, while the underlying neurodegeneration (loss of dopaminergic neurons driven by α synuclein protein aggregation) proceeds unchecked. This stark unmet need - compounded by an aging global population - underscores the demand for novel disease-modifying therapies (DMTs).

Current treatment landscape

All approved PD medications are purely symptomatic. Levodopa (often given with carbidopa/ benserazide) remains the gold-standard for motor control, since it replenishes dopamine in the brain. However, long-term levodopa use invariably causes complications: patients almost invariably develop involuntary dyskinesias (jerky, writhing movements) and 'on-off' motor fluctuations after years of therapy. Dopaminergic agonists (ropinirole, pramipexole, etc.) provide milder symptom relief but carry neuropsychiatric risks: higher doses can induce hallucinations, confusion and impulse-control disorders (e.g. compulsive gambling or hypersexuality). Other drugs - MAO-B inhibitors (rasagiline, selegiline), COMT inhibitors (entacapone), amantadine, anticholinergics– offer only modest additive benefit and each has its own side effects (nausea, orthostatic hypotension, cognitive impairment, etc.). Critically, none of these treatments slows PD progression. Moreover, most do little to alleviate non-motor symptoms; for example, emerging dementia and autonomic failure in PD patients remain largely unaddressed by conventional therapy. Invasive interventions like deep-brain stimulation (DBS) can improve motor fluctuations in selected patients, but DBS is costly and reserved for later-stage disease. In sum, the current armamentarium leaves a large therapeutic gap – symptomatic relief at significant toxicity – and fuels interest in therapies targeting the root molecular pathology.

Market outlook

The PD therapeutics market is expanding rapidly. A recent industry analysis projects that the global PD drug market (nearly $6.2-6.6 billion in 2024) will more than double to ~$13.3 billion by 2034 (8-8.5% CAGR). Aging demographics (increasing numbers of elderly people) and rising PD prevalence are the principal drivers. Similarly, the Indian PD drug market is growing: Grand View Research reports roughly USD 154 million in 2024, rising to ~USD 210 million by 2030 (5.3% CAGR). Factors fueling demand include greater patient awareness and diagnosis rates, expanded healthcare access, and intensified R&D into neuro-protective treatments. In parallel, advocacy and funding initiatives (for example, major grants for PD research) are stimulating the pipeline of potential DMTs. Overall, the combination of a large patient base, high socio-economic burden and lack of curative options makes the PD market highly attractive for innovative therapies.

Our technology

The peptide is designed to attack PD at its root by targeting alpha-synuclein (α syn) aggregates. In PD, misfolded -synuclein proteins accumulate into Lewy-body fibrils within neurons, triggering progressive neuro-degeneration. The NRDC peptide binds anomalous α-syn species and inhibits fibrillization even at sub-stoichiometric doses, effectively halting the pathogenic clumping process. Importantly, this peptide has been engineered for central nervous system delivery. Preclinical data confirm that it crosses the blood-brain barrier after systemic administration.

In vivo efficacy has been demonstrated in multiple models. In transgenic mouse and C. elegans PD models, treatment with the peptide significantly improved locomotor function and reduced brain αsynuclein aggregates compared to controls. These functional and histological benefits validate the mechanism of action. Notably, the peptide is claimed to act at the molecular origin of PD pathology rather than its symptoms. The innovation is protected by patent filings that cover the peptide sequence and its therapeutic use, securing exclusivity for this first-in-class candidate.

Competitive edge

The peptide offers several advantages over existing PD modalities (antibodies, small molecules, etc):

- **Superior CNS penetration:** The peptide is small (<1 kDa) and optimised for brain delivery. Unlike bulky monoclonal antibodies, it readily crosses the intact blood-brain barrier.
- **Intra-cellular targeting:** Crucially, it can enter neurons and neutralise-syn aggregates inside cells. Most biologics (and even many small molecules) cannot effectively reach intracellular Lewy bodies; by contrast, our peptide engages the pathogenic protein in its native compartment.
- **Improved safety:** Being composed of natural amino acids, the peptide degrades into innocuous metabolites. This minimises systemic toxicity and immunogenicity relative to synthetic drugs or protein biologics. The risk of off-target effects or allergic reactions is inherently lower.
- **Flexible delivery:** The peptide can be formulated for patient-friendly administration routes. Intranasal sprays or depot injections are feasible, potentially avoiding frequent oral dosing or intravenous infusions. Such flexibility can enhance adherence and convenience.

Together, these attributes to CNS access, intracellular action, and benign metabolism, give the peptide a significant competitive edge as a disease-modifying agent in PD.

Conclusion

This peptide technology represents a first-in-class disease-modifying candidate for Parkinson's. By directly targeting α-synuclein aggregation at sub-stoichiometric levels, it has the potential to slow or halt PD progression rather than merely masking symptoms. Its preclinical validation (brain penetration, functional recovery, aggregate clearance) and secured patent estate underscore its scientific credibility and exclusivity. Given the rapidly expanding PD market (projected to reach ~$13.3 billion by 2034) and the critical lack of DMTs, this platform offers significant strategic value. In summary, NRDC's approach is poised to redefine PD therapy – shifting the paradigm from symptomatic relief to root-cause intervention – and represents a compelling opportunity for investment in a high-growth therapeutic area.

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NRDC signs MoU with IAF's Regional Aerospace Innovation Division to boost IP and technology commercialisation

NRDC and IAF join hands to accelerate technology commercialisation

National Research Development Corporation (NRDC) has signed a Memorandum of Understanding (MoU) with the Regional Aerospace Innovation Division (RAID) of the Indian Air Force (IAF) to provide IP consultancy and value-addition services for technology commercialisation.

The MoU was formally exchanged between Cmde. Amit Rastogi (Retd.), CMD, NRDC, and Air Marshal Ajay Kumar Arora, Air Officer-in-Charge Maintenance, IAF, in the presence of Air Vice Marshal Tejpal Singh and other dignitaries at the Tri-Services Academia Technology Symposium held on 22 September 2025.

This collaboration with the Armed Forces, under the ethos of 'VivekvaAnusandhan se Vijay', seeks to strengthen innovation, technology transfer, and self-reliance in India's aerospace and defence sector, aligning with the vision of *Atmanirbhar Bharat.*

The Tri-Services Academia Technology Symposium (TSATS) 2025, held from 22 to 23 September at the Manekshaw Centre, New Delhi, was the inaugural joint platform of the Indian Army, Navy and Air Force to engage directly with academia and research institutions. Organised under the aegis of the Integrated Defence Staff, the symposium – built around the theme 'Vivek va Anusandhan se Vijay' (Victory through Wisdom and Research) – showcased over 200 academic innovations, hosted one-on-one interactions with service representatives, and facilitated multiple MoUs to foster collaborative R&D, technology transfer and indigenous solutions. The event marked a significant step towards aligning India's scientific and academic community with the Armed Forces' capability needs in support of Atmanirbhar Bharat.

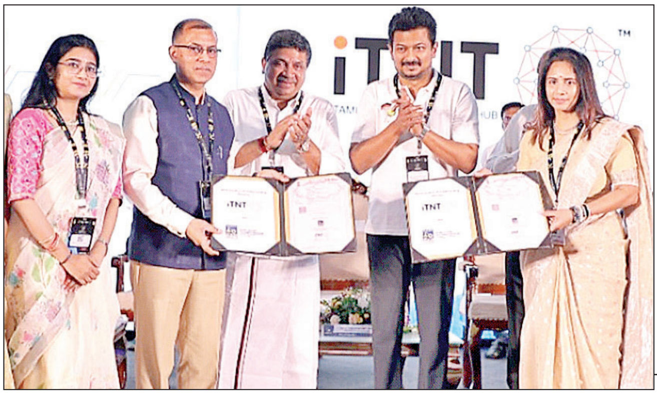
NRDC participates to strengthen innovation ecosystem in Tamil Nadu

The Innovate in Tamil Nadu IP Conclave was inaugurated by Hon'ble Deputy Chief Minister of Tamil Nadu, Thiru Udhayanidhi Stalin, along with esteemed dignitaries including Thiru Palanivel Thiaga Rajan, Minister for Information Technology and Digital Services (IT & DS), Thiru Brajendra Navnit, IAS, Principal Secretary to Government, VanithaVenugopal, CEO, iTNT, and Cmde. Amit Rastogi (Retd.), CMD, NRDC. The conclave, themed 'Intellectual Powerhouse: Transforming Tamil Nadu into the Innovation Capital of India', aimed to shape the State's innovation and IP landscape, establish Tamil Nadu as an IP hub, and promote commercialisation by enabling technology transfer across academia, researchers, innovators, and start-ups.

During the conclave, several important technology transfer agreements and MoUs were signed and exchanged. Among them, the technology 'Recombinant Ectoine from Deep Sea Bacteria for Skincare and Cosmetic Applications (REB)', developed by the National Institute of Ocean Technology (NIOT), was transferred to M/s VareeAyustruct

Ventures Pvt. Ltd., Visakhapatnam by NRDC. In addition, NRDC signed a collaborative MoU with Tamil Nadu Technology Hub (iTNT), affirming their shared commitment to advancing innovation, facilitating technology transfer, and building capacities to strengthen the Tamil Nadu innovation ecosystem. Cmde.Amit Rastogi (Retd.), CMD, NRDC, also presented a comprehensive Technology Compendium featuring ready-to-commercialise technologies for MSMEs and start-ups to the Hon'ble Deputy Chief Minister. The presentation underscored NRDC's strong commitment to fostering entrepreneurship, technology transfer, and industrial growth in Tamil Nadu.

NRDC transferred the 'Recombinant Ectoine from Deep Sea Bacteria (REB)' technology, developed by NIOT, to M/s VareeAyustruct Ventures Pvt. Ltd., Visakhapatnam for skincare and cosmetic applications


NRDC signed a collaborative MoU with Tamil Nadu Technology Hub (iTNT) at the Innovate in Tamil Nadu IP Conclave

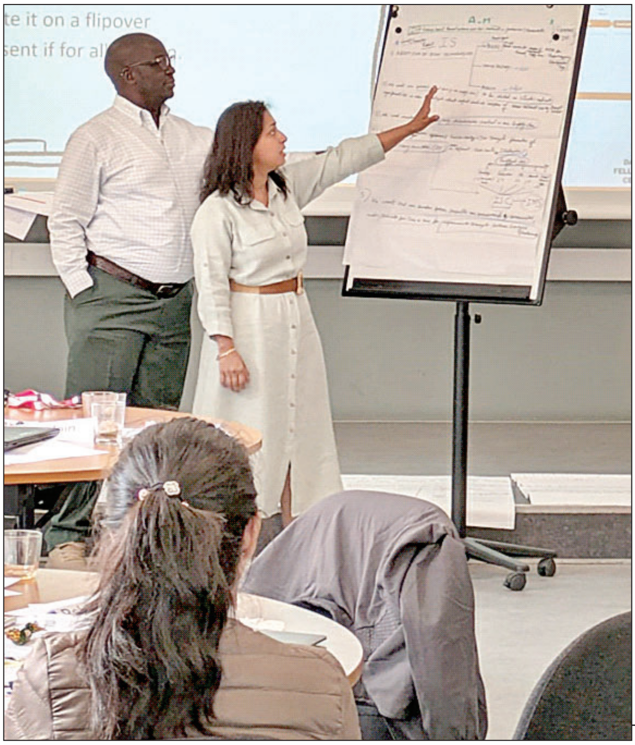
NRDC officials interacting with visitors at the stall

NRDC interacts with technology stakeholdersat international MSME platform

The National Research Development Corporation (NRDC) participated in the 11th India International MSME Expo & Summit 2025, held from 28 to 30 August 2025 at Bharat Mandapam, Pragati Maidan, New Delhi. The event served as a platform to showcase NRDC's portfolio of technologies and services to MSMEs, start-ups, and industry stakeholders. At the NRDC stall, a range of innovations attracted significant attention, including Agri and Food Technologies such as biodegradable packaging films and food processing solutions, as well as healthcare and biotech products like diagnostic kits and biomedical devices. The Corporation also highlighted its core services in technology licensing, incubation, IP management, and commercialisation support. NRDC officials interacted with visitors and briefed them about the Corporation's commercial and promotional activities, further enhancing engagement and awareness. The expo witnessed robust participation from diverse MSME sectors, with a strong emphasis on packaging and food-tech, which align with NRDC's focus areas. Several stakeholders expressed keen interest in exploring collaborative models with NRDC and its licensees.

(Compiled by NRDC Officials)

NRDC participates to represent India at the DANIDA fellowship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Dr. Akanksha Jain (Deputy Manager) representing NRDC and India at DANIDA Fellowship Centre (DFC), Denmark selected for Training Programme on ISO Innovation Manager sponsored by Ministry of Foreign Affairs, Denmark

At NRDC, we believe that continuous learning and capacity building are the foundation of excellence in technology transfer and allied activities. In this spirit, NRDC nominated Dr. Akanksha Jain, Deputy Manager, for the prestigious DANIDA Fellowship Programme on 'ISO Innovation Management'. Her application was selected by the DANIDA Fellowship Centre, under the sponsorship of the Ministry of Foreign Affairs, Denmark, bringing together participants from across the world.

It is a matter of pride that Dr. Akanksha represented India in this global programme, alongside three participants from eminent institutions such as IIT, NID, and Cochin Shipyard.

The main objective behind NRDC's nomination was to encourage capacity building of its employees in areas relevant to its mandate of technology transfer and commercialisation. By gaining international exposure and training, NRDC seeks to integrate global best practices into its systems and strengthen its innovation management culture.

The course on Innovation Management was not limited to theory but emphasised the practical adoption of standards to address real-world challenges faced by organisations. Innovation, in its true sense, is when novelty leads to value realisation– whether social, environmental or economic. Often, innovations are created and forgotten; however, the ISO 56000 standards provide a structured framework to measure impact, both qualitative and quantitative. This ensures that innovations contribute to continuous improvement rather than one-time outcomes.

Thus, managing innovation is not about justification of efforts, but about driving a cycle of learning, improvement, leadership and strategic vision that sustains growth.

For NRDC, such initiatives ensure that our employees remain aligned with global best practices, strengthening our culture of innovation and motivating our team to manage change with vision and strategy. I am confident that the learnings from this programme will bring tangible benefits to NRDC and further reinforce our role as a national leader in technology transfer and commercialisation.

Dr. Akanksha Jain
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E-mail: ajain@nrdc.in

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Salient Features

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- Optimized dye extraction and mordanting process
- Low water, energy, and chemical usage
- Good wash, rub, light fastness
- Supports traditional & rural artisans

Advantages

- Non-toxic, non-allergenic – safe for skin
- Reduces water and chemical pollution
- Aesthetic, natural color tones
- Low-cost and scalable for MSMEs and artisans
- High color yield and durable finish

Applications

- Textile & Apparel Industry
- Handloom & Handicraft Sector
- Sustainable Fashion Labels
- Research & Education in Green Chemistry

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